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JUNE 1958

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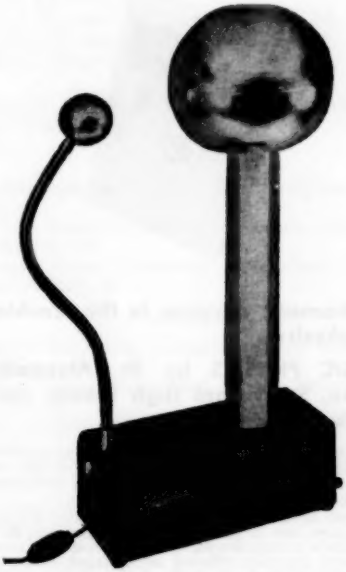

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SOCIAL FACTORS IN THE MOTIVATION OF ENGINEERS AND SCIENTISTS*

DONALD C. PELZ
Assistant Program Director, Institute for Social Research, University of Michigan

The question before the panel this afternoon—the motivation of technical personnel—is a complex and challenging one. As the afternoon proceeds you will notice that there is a division of labor among us, both as to the sources of motivation we shall be talking about, and as to the research methods used for securing insights. My own focus will be on some of the social factors which enter into the motivation of engineers and scientists.

In the area of social factors, we can raise the general question: What kind of a working environment—what kind of relationships with colleagues and with superiors—will stimulate an engineer or scientist to his highest performance? To be more specific, we can ask: to what extent should scientists and engineers be organized to work in teams or as individuals? To what extent should technical employees be encouraged to work with colleagues whose training or interests are similar to their own or dissimilar? How fruitful are interdisciplinary teams? Should research laboratories be organized by projects or by scientific disciplines? And what role shall be played by the supervisor of technical personnel? Should he, for example, work closely with his subordinates, or should he adopt a hands-off policy and see them only occasionally?

* A paper presented at the meeting of the American Society for Engineering Education, January 30–31, 1958, Ann Arbor, Michigan. The report is based in part on a study supported by the National Institutes of Health, United States Public Health Service, Department of Health, Education and Welfare. Additional analysis and writing were made possible by a grant from the Foundation for Research on Human Behavior, Ann Arbor, Michigan.

These are difficult and complex questions. I am sure that there are no ready answers which one may set down as "ten rules for supervising technical personnel." The specific nature of the job to be done, the previous history of the organization, the characteristics of the individual employee—all these factors must be weighted by a sensitive manager in making his day-to-day decisions. For a long time to come, the administration of technical personnel must remain a subtle and intuitive art. Our hope is, though, that research data can be accumulated which will begin to give an objective scientific foundation upon which a research manager can make his decisions.

The data I am going to talk about this afternoon are a very long way from constituting a set of rules for the supervision of technical personnel. Yet I hope they may provide a few clues against which a research executive can check his intuitions. We hope that results such as these are a first step toward making the administration of research organizations more of a science, rather than the refined art which it necessarily is today.

The Research Approach Used

How does one go about getting research data that bears on the questions I have raised? Two alternative approaches are possible. One is to ask people what kinds of working environments they prefer. How closely do they like to work with colleagues, and with what kinds of colleagues? What relationships with their supervisor do they prefer? Drs. Danielson and Riegel used such an approach, and I know that from it they have gathered many valuable insights, which they will present to you this afternoon.

In the data I shall present, we used a different approach. First, in a research organization we obtained a rough measure of the caliber of scientific performance of different individuals. How this was done I shall describe in a moment. Second, by questioning the individuals we attempted to find out the nature of their working environment—the kinds of relationships each individual had with his colleagues or his supervisor. Then we analyzed the data to see what social factors actually distinguish the higher performing scientists from those performing less well. From this type of analysis we hope to get clues to social factors that might contribute to the high or low performance. In this approach we seek to secure answers by analyzing data, rather than by asking individuals about their preferences.

Now, a word on how we measured scientific performance of individuals. The data were obtained in a government organization for medical research employing some 300 scientists. Essentially, we relied on the pooled judgments of a number of senior investigators who were thoroughly familiar with the work going on in their laboratories

and in their disciplines. About one-fifth of the scientific personnel served as judges. Each judge was given a list of the individuals in his own laboratory, and also those in other laboratories within the same scientific discipline. The judges placed the personnel in a rough rank order with respect to level of their current scientific performance.

In making their evaluations, the judges were asked to imagine themselves as serving on a committee making research grants. To whom would they be most willing to award a research grant? Who, in their estimation, would be most likely to turn out significant research in the next few years? Where judges could not agree on an individual, that person was eliminated from our analysis. Where there was moderate agreement, the evaluations of from two to eight judges on each scientist were pooled to arrive at an average performance score.

Amount of Freedom and Scientific Performance

First let's take a look at the research supervisor. One of the important factors which differentiates supervisors of technical personnel is the amount of freedom allowed to subordinates. We have been much concerned with this dimension. In the organization, each of the scientists filled out a questionnaire on which he described, among other things, the typical nature of relationships with his supervisor. In one analysis we took a look at the immediate work groups in this setting—a group being defined as two or more scientists, roughly of the same job level or grade, reporting to a common chief. Because of the large differences in supervision given to the younger as against the older scientists, we studied the data separately for "junior" and "senior" levels. Most of the investigators have a doctoral degree, with "junior" level people having only a few years of experience beyond the Ph.D.

On the questionnaire, each respondent indicated how decisions were typically made about what problems were to be undertaken. Were such decisions made by the chief, jointly by the chief and the investigator, or were they generally left up to the investigator himself? Scientists were also asked how much influence they felt they had, in general, on decisions which the chief made affecting them. These data were combined into an over-all measure of *dependence or independence* shown by members of each work group in relation to their immediate chief.

In Exhibit 1 are shown data for junior level scientists. At one extreme is "dependence"; in this type of relationship, none of the scientists makes his own decisions on what projects to undertake; all report that the chief has considerable influence on their work. At the opposite extreme is "independence," in which the reverse is true:

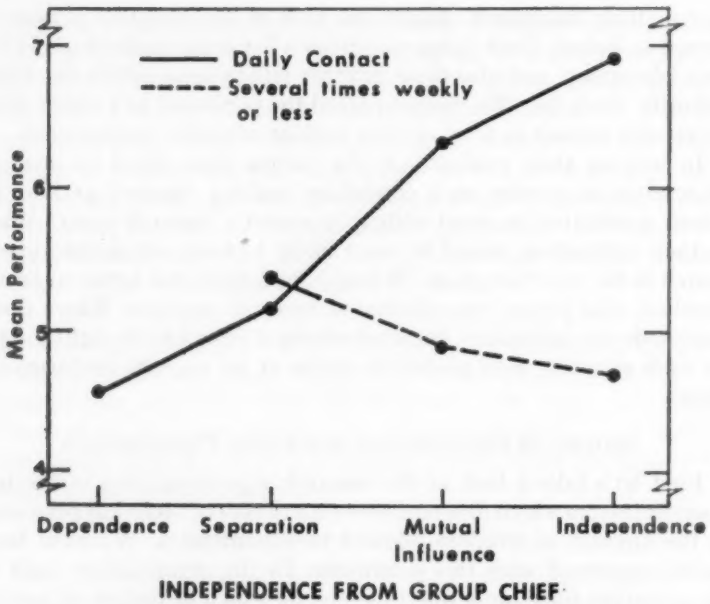


FIG. 1. Scientific performance as related to independence from group chief, and contact with chief (at junior level).

many of the subordinates make their own decisions, and report the chief as having little influence on their work. There are two intermediate categories. Under "separation," neither the subordinate nor the chief has much to say; under "mutual influence," both have a good deal to say. Along the vertical axis is the average standing on scientific performance as measured by the ranking technique described earlier.

IMPORTANCE OF FREQUENT CONTACTS

Our first analysis with this scale was disappointing. Persons in the four categories showed little difference from each other in terms of scientific performance. But further scrutiny brought out an interesting pattern. We separated the scientists into those who have frequent contact with their chief (once a day, on the average, or more often) and those who have infrequent contact with him (only a few times a week, or less often). For those who see him weekly (lower curve of Fig. 1), the performance curve is flat among the four categories and even declines with independence. But for those who see the chief daily, the highest performance is shown by those who have considerable independence in pursuing their own work, but at the same time maintain close daily relations with the chief.

What goes on in these daily encounters? We aren't sure, exactly; this is one of the areas that we are pushing further in our current studies. In all probability, the chief—by frequent inquiries—shows his interest in and enthusiasm for the work, and this is something on which a young scientist thrives. The chief may offer hints as to methods; he may refer to relevant publications; he may simply express his confidence in the progress that is being made. His very presence may serve as a motivating factor, causing the young scientist to push ahead as rapidly as he can, knowing that his chief will take pleasure in the results.

We are becoming more and more convinced that this active interest in the ongoing work, combined with a hands-off policy concerning its direction, is one of the most fruitful things that a research chief can do—particularly with his younger personnel. But this is not an easy thing for a leader to do. A competent chief who keeps in touch with his subordinates' work finds it natural to impose his own ideas. Or, if he wants to give them a free hand, it is all too easy to leave them isolated. To achieve the proper balance between interest and isolation is a feat which requires a great deal of skill in human relationships.

Relations with Scientific Colleagues

Turning next to the technical man's professional colleagues, we may consider questions such as: how much interaction with colleagues is desirable for maintaining high motivation and performance? Does a cooperative approach to problems help or hinder the individual researcher? Again there are several ways of getting data to answer such a question. One may ask scientists how they feel about working individually or cooperatively. Alternatively, one may examine situations in which there is relatively much or little interaction, and see if there is in fact any noticeable difference in the caliber of performance under the contrasting conditions. Again, the data I shall show you were obtained by the latter approach.

In the same government organization, we asked each respondent to indicate on his questionnaire the people in the organization with whom he regarded some contact of some significance for his work. For the present analysis Glen Mellinger and I used the five professional associates whom the scientist named as most significant, excluding supervisors, administrative and clerical personnel, and technicians.

At first we made little progress in our search for a significant correlation. There was no indication, for example, that scientists who see their colleagues frequently perform any better or worse than those who rarely see their colleagues.

We then asked: Does the ***kind*** of colleague make a difference? Does a productive scientist name colleagues who have the same motiva-

tions, training, and experience as himself, or does a productive scientist usually contact colleagues who are different from himself in important respects?

Let me digress a moment to describe how we measured factors such as motivations, training, and experience. One such measure we called type of "professional orientation." In the questionnaire we asked what kind of factors the individual regarded as essential in a job. For example: how much importance did he place on the opportunity to contribute to basic scientific knowledge? How much stress did he place on having freedom to follow his own ideas? How much did he value a chance to use his abilities and knowledge? We found incidentally that these three emphases are inter-related—namely stress on contributing to knowledge, on freedom, and on using abilities. We therefore called this cluster of items an indication of individual's "orientation toward science."

A second cluster of items on the questionnaire concerned prestige and advancement within the organization. Some individuals placed rather strong emphasis on the opportunity to hold an important job in the organization, on associating with high level persons, on belonging to an organization that has high prestige in the eyes of the community. We called this cluster of items an "institutional orientation" —implying that the individual seeks recognition within the particular institution, rather than within the broader scientific fraternity. Individuals who are high on "science orientation" are mainly people who would go back to universities if they were to leave. People who are high on "institutional orientation" would mainly prefer to work in other government organizations, if they were to leave this one. Those with a strong institutional orientation, we should note, also tend to stress the applied value of the research work they are doing.

For each scientist we compared his professional orientations with the orientations of his major colleagues, and we assigned each respondent a score based on similarity or dissimilarity between himself and his colleagues in these orientations or "values."

Let me describe a second measure of similarity which we developed. Here we studied the scientist's previous experience. Before coming to this organization, in what kind of institution had he worked—university, government, hospital, industry, and so forth? Based on a number of previous situations that a scientist and his colleagues had in common, a similarity score was assigned, and the average similarity between each investigator and his five colleagues was obtained.

Our first results, as I said, were disappointing. On the average we found that productive scientists in general are no more similar to nor different from their colleagues than are unproductive scientists.

However, when we analyzed the results by using both the frequency of contact with colleagues and similarity to them in the type of orientation and previous experience, a highly intriguing pattern emerged (Fig. 2). This analysis, by the way, has been done so far only for the senior level; we do not know what the picture is for junior level scientists.

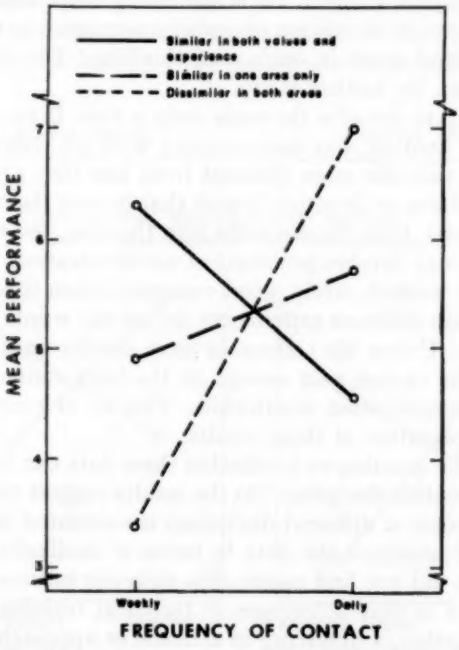


FIG. 2. Scientific performance as related to similarity in values and previous experience with five colleagues, and frequency of contact (at senior level).

We broke the scientists into three categories. One group (represented by the solid line) consists of scientists who name colleagues who are similar to them, both in their orientations (or "values") and also in previous experience. Another category of respondents (the dotted line) consists of those who are dissimilar to their five colleagues, both in their orientations and in previous experience. Finally there is a group in-between (dashed line) who are similar to their colleagues in one area only, while dissimilar in the other.

A striking pattern emerges: When the scientist names as colleagues those who are markedly dissimilar to himself—both in terms of values and experience (dotted line)—then if he sees them daily, his performance is very high. If he sees them only once a week, his performance is very low. The opposite picture emerges if his colleagues

are individuals who have very similar values and previous experience (solid line). Here, if he sees them weekly, his performance is good; but if daily, his performance is poor.

It almost appears as if too much contact with the same kind of individuals can be dangerous to an individual's scientific creativity. Why should this be so? Is it simply that individuals are wasting time in meaningless bull sessions? Or is something more insidious setting in—a reinforcement of existing prejudices, perhaps—so that one cannot see the blind spots in one's own thinking? This is certainly a fascinating area for further study.

Another way to describe the same data is this: If the scientist, for one reason or another, has daily contact with his colleagues (right-hand points), then the more different from him they are, the better. But, if his problem or situation is such that he sees them only weekly (lefthand points), then the more like him they are, the better.

This result may involve problems of communication. If a scientist sees his fellow workers rarely, good communication is hard to establish. People with different experiences do not use words and terms in the same way. Unless his colleagues have similar backgrounds and orientations, he cannot gain enough in the brief contacts he has to make the communication worthwhile. This is, of course, only one possible interpretation of these results.

We raised the question as to whether these data can be interpreted in terms of scientific discipline. Do the results suggest that daily contact among people of different disciplines is associated with high performance? We analyzed the data in terms of similarity in scientific discipline, but did not find nearly this clear-cut pattern. Our tentative conclusion is that differences in technical training are not the crucial key. Rather, a difference in attitude or approach seems to be more important—a difference, perhaps, between theoretical and practical ways of attacking problems. But much research will be needed before we can specify what the essential nature of this fruitful dissimilarity may be.

The One Most Significant Colleague

After we had obtained these findings on the relations between the scientist and his five most significant colleagues, we became curious about a further question: What about the scientist's one most significant colleague? Will we find that our investigators work at their best when they can cross intellectual swords with one close associate having a different viewpoint? We took the individual named as the single most important colleague and repeated our analysis. This time we were able to study the junior as well as the senior level.

In Fig. 2, we noted that the dotted line showing dissimilar col-

leagues slants upward with daily contact, and the solid line showing similar colleagues slants downward. Now, using only the single most important colleague (Fig. 3), we again have a criss-cross effect—but in the opposite direction! In other words, performance goes up when there is daily contact with one colleague having the same values; and performance goes down when there is daily contact with one colleague having dissimilar values. And these results exist despite the fact that the data for this colleague have been included in the averages for the five! This pattern is found for both senior and junior personnel.

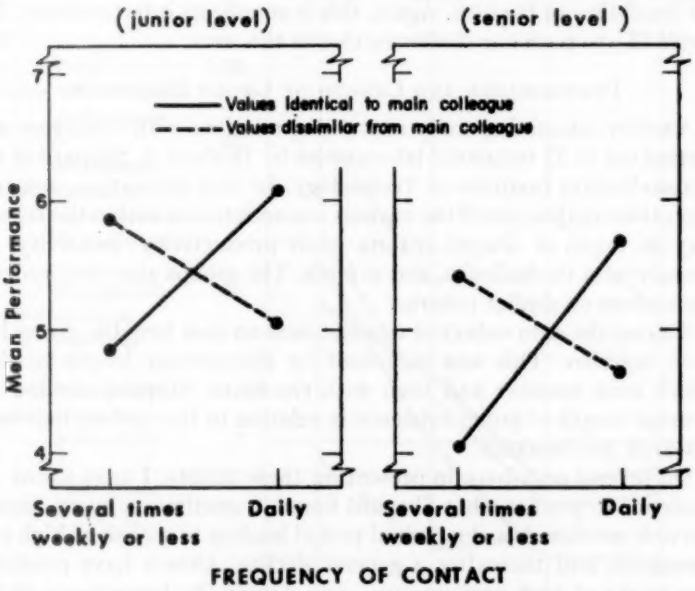


FIG. 3. Scientific performance as related to similarity in values and frequency of contact with main colleague.

This surprising result reminds one of some experiments in social psychology performed by Solomon Asch. He used groups of subjects ranging in number from 3 to 10, and asked them to make simple judgments like estimating the length of lines. Actually, only one of the subjects in each trial was naive; the others were instructed in advance. In certain critical trials the other subjects unanimously gave the wrong answer. The experimental subjects became flustered and upset, and in one-third of the trials they too gave a judgment which their senses told them was wrong.

The critical point is that if even one other member of the group

disagreed with the majority, the error effect was sharply reduced. If the subject had only one other person to support him, he was able to maintain his opposition to the majority. We believe that something similar may happen in a scientific group. If the group consists of people with differing viewpoints and backgrounds, it may be highly stimulating; but there is the danger that one individual may seem a crackput to the others when he comes up with a wild idea. He may be laughed down, and may give in to the group pressures. In such situations it may be essential for him to have the emotional support of one or two other persons who have the same viewpoint as his, and can see the feasibility of his idea. Again, this is simply an interpretation. We would like to push our studies further in this area.

Performance and Length of Group Existence

Another interesting study concerning relations with colleagues was carried out in 21 industrial laboratories by Herbert A. Shepard of the Massachusetts Institute of Technology. In each laboratory, research executives rank-ordered the various research teams within the laboratory in terms of several criteria: their productivity, creativity, responsiveness to challenge, and so forth. The groups also rank-ordered themselves on similar criteria.

Among the data collected was one item on how long the group had been together. This was measured by the average length of time which each member had been with the team. Shepard studied the average length of group existence in relation to the various indices of research performance.

On several occasions, in presenting these results, I have asked the audience to predict what Shepard found. Sometimes a hump-backed curve is predicted: a slow initial period leading to a peak of high performance, and thereafter a general decline. Others have predicted two peaks of high performance—one during the honeymoon of the first few months and another after several years. Other listeners have predicted a steadily rising curve as individuals got to know each other and were able to function smoothly together. Still other predictions were for a steady decline, after the first rich ore was mined and the routine of mopping up details was taken on.

The findings actually are as follows. We know the situation only for groups whose average life is 18 months or more; there were too few of shorter duration to study. The data obtained by Shepard (Fig. 4) shows that, from the point of 18 months onward, there is a continuous decline in the productivity of his research groups, in several ratings made by management, and also in ratings which the groups made of themselves. (You understand, of course, that these

are different groups which vary in their group age, not the same groups observed over a period of time.) The result is clear. For whatever reason you choose to accept, a relatively "new group" of under 18 months is seen by both management and by its members as performing better than a relatively old group of more than five years' duration.

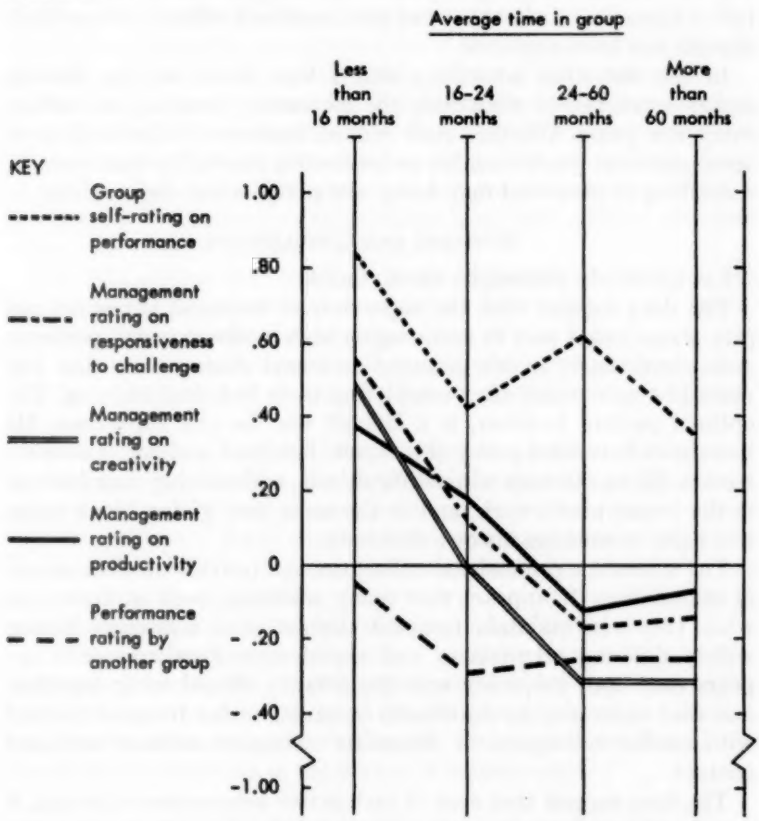


FIG. 4. Performance ratings of groups, against average time in group.

These results, by the way, are independent of the individual ages of members. Whether we look at relatively young or relatively older people, we find the same result: Those in short-lived groups see themselves—and are seen by management—as performing better than those in relatively long-lived groups.

What are the implications? Again, we have no proof of the casual

connections. However, I would like to stress one possible interpretation which is consistent with the previous data. Each individual has, to some extent, unique experiences and unique ways of approaching problems. A new grouping of individuals will almost by definition bring a new set of skills and approaches to bear on any problem. It may be that, after a group of people have worked closely together for two or three years, what they can gain from each other as unique individuals has been exploited.

In one industrial laboratory that I have heard of, the director makes a practice of reshuffling the laboratory from top to bottom every few years. Whether such radical treatment is justified is an open question. But it remains an interesting possibility that periodic reshuffling of personnel may bring new perspectives and new zest.

Summary and Conclusions

Let me briefly summarize these results.

The data suggest that the supervisor of technical personnel can play a significant part in encouraging high motivation and performance, particularly in his younger personnel during their first few years of employment after completing their technical training. The optimal pattern however, is a difficult one for any supervisor. He must steer between a policy of complete hands-off and one of over-direction. He has to maintain a difficult role, maintaining close interest in the young man's work, and at the same time giving him a fairly free hand in reaching his own decisions.

The scientist's professional colleagues can provide another source of stimulation. It appears that many scientists work at their best when they can maintain frequent contact with colleagues having widely differing orientations and experiences. Furthermore it appears that both frequency and dissimilarity should occur together, and that there may be drawbacks in having either frequent contact with similar colleagues, or dissimilar colleagues without sufficient contact.

The data suggest that even in such active heterogeneous groups, it may be wise to have one or two like-minded colleagues to whom one can look for support of one's bizarre ideas.

We also noted that some individuals flourish under quite different conditions—that of isolation from colleagues, where whatever contact they do have is with people of similar orientation. Further research is needed before we can specify what kind of individuals flourish best, or what kind of problems are most appropriate for attack, under these opposite conditions of interaction and isolation.

Finally, some data from a number of industrial laboratories showed that groups which have been together longer tend to perform less

well. It may be that periodic re-grouping of personnel is one way to provide fresh ideas.

What, then, are the practical implications of these data? One place to look, clearly, is the supervisor and his relations with his younger personnel. A man who has been promoted to position of chief on the strength of his technical accomplishments, may find it difficult to avoid outright direction of a younger man's work. Coaching the chief as to this relationship may prove helpful, if our long-range goal is to develop young scientists so as to make full use of their potential.

The data suggest furthermore that where the situation encourages frequent contact between scientists, the group may perform better if it is composed of people with varying viewpoints, rather than being all of like mind. Getting theoreticians to interact with experimentalists, getting basic scientists to exchange ideas with applied scientists —these are possible sources of stimulation.

The data suggest that stimulation can be gained by organizing according to the project to be accomplished rather than by discipline, providing there is sufficient communication. Where little communication occurs between scientists, then the project-type organization may have dangers and an organization by discipline may be preferable.

Finally, the data suggest that a research organization should avoid crystallizing its structure. Under pressure to provide promotions, a research laboratory may be tempted to create an elaborate structure with several layers, many small sections, and many supervisory slots. This seems unwise, as it freezes the group structure. A man who has gained status by being put in charge of a group may resist the loss of face that occurs if the group is broken up and reassembled.

All these suggestions are offered in a tentative fashion for your discussion and debate. We are very far as yet from drawing firm conclusions. We have made a few steps toward gaining objective scientific data on the administration of research. Clearly, we are just at the threshold of a vital area in the science of management.

FROST DAMAGE IN CITRUS FRUIT CAN BE DETECTED BY X-RAY

The first potentially practical method for detecting frost damage in citrus fruit mechanically has been developed by engineers at the University of California at Los Angeles.

The machine measures frost damage by beaming X-rays through fruit rotating on a platform. The resistance encountered by the X-rays is registered as a voltage reading. As the damage done by frost increases, the voltage reading increases due to the non-uniformity encountered by the X-ray. Non-uniformity of fruit sections is characteristic of frost damage.

WHY DIDN'T THEY TELL ME?

CECIL B. READ
University of Wichita—Mathematics Editor

Some half dozen years ago SCHOOL SCIENCE AND MATHEMATICS published a series of letters dealing with the teaching of collegiate mathematics. Several teachers with years of experience cooperated, each writing a letter such as might be written to a young friend just starting his teaching career. As might be expected, there was not unanimity of opinion; nevertheless many favorable comments were received on the series.

Although the approach unquestionably has merit, the other side of the picture needs consideration. When the beginning teacher of mathematics is in the midst of the problems of his first year or two of teaching, does he believe there is information which he did not receive earlier, which would have been of help in his teaching work? With the idea of in some way presenting this viewpoint, a series of letters will be published. Members of the Central Association of Science and Mathematics Teachers engaged in teacher training activity cooperated by suggesting the names of beginning teachers (i.e., those in their first or second year). Several of these young teachers were asked to write a letter such as might be sent their college, their professor, or a colleague, pointing out some of the problems which should have been or at least could have been discussed while preparation for the profession was under way. Unlike the first series, this set of letters has not been restricted to the collegiate level An attempt has been made to obtain letters from teachers in various parts of the midwest, with preparation at various colleges and universities

As might be expected, points will be raised by one teacher which another teacher might feel were adequately covered in his preparation; there may be some repetition, and of course differences in opinion. In no case has there been any change in the letter as originally submitted without first obtaining the approval of the writer.

Maine Township High School
Des Plaines, Illinois
January 8, 1958

Dear Professor:

I am well pleased with my teaching position at Maine Township High School. I like teaching in the large high school, but I am glad to have had experience in a small high school.

Having been in the field of teaching for a while, I feel there is one thing in particular which should be pointed out to prospective mathematics teachers. That is the use of different number systems as an aid in teaching a course in "general mathematics," which in our school consists of work in remedial

arithmetic. Students enrolled in the course are slow learners and most of their previous experience with arithmetic has been distasteful. They have little interest in arithmetic and are mechanical in performing arithmetical processes. Thus to reteach these processes proved to be of considerable difficulty. Even more difficult was to unteach some of the undesirable concepts they had formed. Working with a number system which is based on a number different from ten served as an effective means for overcoming these difficulties. This work in a different number system demanded an understanding of the arithmetical processes. It was most encouraging to watch these students work with interest and enthusiasm. After working with three or four different number bases, the students returned to working in base ten with new insight.

I am planning to attend the meeting of The National Council of Teachers of Mathematics in Colorado this summer. Hope to see you there.

Sincerely yours,
DAVID PAISLEY

210 Home Street
Sycamore, Illinois
February 5, 1958

Dear Mr. Read:

I am very honored at your request for the following letter. I hope this is what you had in mind;

". . . I have found in all of the courses I teach, the hardest part is not in preparing the lesson, but to devise a method of presentation which will prove both informative as well as interesting. When I started teaching, I went into the classroom with a feeling of confidence because I thought I was prepared to teach, only to find I could not do a good enough job to really hold their interest. Nothing was lacking as far as subject matter was concerned, but something *was* lacking in my presentation. Possibly somewhere in my previous training more time should have been spent on how to teach a class. While student teaching helps considerably, there is a great difference when you are completely on your own.

Another grave problem is that of attitudes of the students. I have found that with some of my students, especially in practical mathematics, there is a never ceasing war with their ideas conflicting with mine. Maybe I should be more of a psychologist!

To any beginning teacher it should be known that there will be small problems that arise. They should never be afraid to go to any of their superiors to obtain information on these problems.

It is impossible to record actual experience into book form for college students to read but perhaps more stress on the presentation and handling of a class should be made."

Very truly yours,
RUFUS ROBERTS, JUNIOR

SURGICAL THREAD GETS ATOMIC STERILIZATION

The catgut used for surgical stitches is now being sterilized by atomic energy at Ethicon, Inc., a division of Johnson and Johnson.

The atomic sterilization process which has been in the experimental stage for 10 years, became a full-time commercial process today.

The sutures are sterilized after they have been put in their sealed containers by bombarding them with high speed electrons.

Three major advantages for the new process are the elimination of the danger of recontamination after sterilization; greater tensile strength in the suture than is found in heat-sterilized catgut; and 10 times the safety margin for the surgeon.

PARAPSYCHOLOGY AND ESP

JOHN G. READ
School of Education, Boston University, Boston, Massachusetts

There are at least two areas where the problems of education overlap the problems of parapsychology. One is in science education, where causal relationships, some physical phenomena, and animal behavior are the subjects of many questions by children and young people, the answers to which must frequently be, "No one knows." The other is in the design of educational experiments.

That little has been published having to do with the relationships between the two fields is not surprising. Statistical methods in educational research and in research in parapsychology are both young. Both have been pressed hard to keep up with their own problems. Further, many experimenters in one group are unfamiliar with the progress made by the other group, and are sometimes critical of assumptions and conclusions made by workers in the others' field. A few studies deliberately planned to include both parapsychology and education would be one means of investigating the research completed or now under way.

In the last few years investigators *have* been gathering data on animal psi-phenomena. Many instances of the ability of animals to find their way home after being deliberately "lost" are known. Turtles do find their way to water from distances presumably too great for the usual senses to help in orientation. Pigeons and migrating wild birds are able to use "flyways" that are not known to be physical guides for birds hatched each Spring. The whole field of instinct, now being examined anew by serious science writers, offers opportunities for psi research by high school and college students. The very history of natural science writing since John Burroughs began to "de-bunk" the nature-fakers, down to Rachel Carson and Donald Culross Peattie, shows that careful observation serves only to pose more problems about animal behavior.

At a somewhat higher level, the question of causation appears. At the sub-atomic level, the terms "indeterminancy" and "probability" appear. Most research in physics, chemistry, engineering, and medicine can afford to ignore all but causative agents of events. But in the clinic, psychosomatic medicine finds more and more patients classified under its label. If current reports on hypnotic and suggestion therapy are true, then physical changes are not uncommon as a result of extra-sensory procedures. Basically, all biology is concerned with more and more accurate descriptions of its processes, and first causes are unknown. (This idea, of course, has been around for some 2500 years.) The point is that young teachers should be ready and

willing to review any research into parapsychological fields, and should present the evidence to pupils in the same manner as they report biological and medical advances. A study of a hive of bees or of an ant colony is bound to bring up some of the questions hinted at just above. The words "natural," "inherited," and, again, "instinct" offer challenges that can be met in the average classroom. Indeed, there is no other field of real experimentation and research so likely to engender a careful plan and a cautious conclusion as is this area.

Teachers in public schools and teachers colleges have very little contact with literature about extrasensory perception (ESP). It would seem reasonable that the psychology courses offered for teachers should spend some time in presenting the large body of research in psi-phenomena, and should call attention to the existence, in our classrooms, of possible "sensitive" subjects in this area. Some planned experiments dealing with *educational* problems should be reported by psi researchers, and the results published in educational journals.

The multiple-choice test is very like the devices used in ESP experiments. There is the element of chance to factor out, and the correct answer is more or less "recognized" in many items. That is, the process is often simple recall rather than problem-solving. As stated above, statistics derived from scores on such tests are considered in the light of chance versus better-than-chance. If the testee begins to mark answers rapidly, perhaps having to complete several score or a hundred at one sitting, he can easily drop below the completely thoughtful level and begin to mark answers in some other way. It may be that successes in the latter part of a long test are not all due to learning in the usual sense. It is such experiments which could well be made by either psi research or by educational research—or better, by the two working together.

It is presumptuous to speak for a group, but the following opinions are probably held by many educators (in 1958). "Parapsychology is an infant science, and its statistical techniques have not been crystallized, especially as to controls." "Statisticians are agreed on the techniques used, but there are not enough replications of the experiments for laymen to feel confident that the results are significant." "The idea that psi-sensitive subjects are operating only on the unconscious level is disturbing." "Psi-phenomena's complete dissociation from physical causes, by definition, is distasteful to the amateur experimenter. Perhaps he might be allowed to present *theories* as to physical causes. For instance, the leakage of the potential of the Earth is certain, so why not might it leak (in dowsing) most rapidly through metals and ionized water? In general, in looking for statistical results, to exclude the *possibility* of discovering a physical cause is nonscientific." "There is some likeness between that educational experi-

ment, never repeated, and the psi experiment, which cannot be repeated because of the variability of the operator. *Operator* for education means a group of children, for ESP, the subject." "The community's attitude toward ESP is such that the public school should not be an experimental field." "It would be helpful to have a summary of actual results to present to young teachers-in-training."

Finally, one thing is certain. More knowledge of ESP and its methods is a concern of the educator, for it is concerned with communication—his specialty.

TEACHER EDUCATION TODAY FOR THE SCIENCE AND MATHEMATICS TEACHERS OF TOMORROW

A REPORT FROM THE MIDEAST REGIONAL STATE COLLEGE CONFERENCE ON SCIENCE AND MATHEMATICS TEACHER EDUCATION

The Mideast Regional State College Conference on Science and Mathematics Teacher Education was held in Washington, D. C. on March 7 and 8, 1958, under the sponsorship of the Science Teaching Improvement Program of the American Association for the Advancement of Science.* The original stimulus for this conference was provided by Dr. John R. Mayor, Director of STIP, following the successful completion of a similar conference, also sponsored by STIP, in the Midwest last year. The purpose of these conferences is to bring together representatives of the mathematics and science faculties of the state colleges in order that they may have the opportunity to exchange views with others concerning current developments in science and in better teaching of science. Since a large percentage of the future teachers in our public schools will be produced in these state colleges, and since experimental programs in education are being conducted in many of them, it is also desirable that representatives from these institutions meet with representatives of the organizations interested in improving the teaching of science in the high schools.

Participants in the Mideast Conference included representatives of the science and mathematics departments of state colleges of the District of Columbia, Maryland, New Jersey, New York, Pennsylvania, Virginia, and West Virginia; high school supervisors of science and mathematics from the Washington metropolitan area; and other leaders in science and mathematics education. In all, approximately 100 persons participated in the conference.

The report that follows deals with the presentations at the mathematics sections. The report dealing with the deliberations at the science sections will appear in a later issue of this journal.

* This conference was made possible through grants from the Carnegie Corporation of New York and the General Electric Educational and Charitable Fund.

PROMISING PRACTICES IN MATHEMATICS TEACHER EDUCATION

A REPORT FROM THE MATHEMATICS SECTIONS OF THE AAS MIDEAST REGIONAL STATE COLLEGE CONFERENCE ON SCIENCE AND MATHEMATICS TEACHER EDUCATION*

COMPILED BY JOHN A. BROWN
Professor of Mathematics, State University Teachers College, Oneonta, New York

There will be two parts to this report. Part I will include abstracts of the invited papers. In Part II are the reports of the Discussion groups. In some instances, the parts of the abstracts included in this report were selected by the one who prepared the compilation.

PART I. INVITED PAPERS

IMPLICATIONS OF THE WORK OF COMMISSION ON MATHEMATICS IN TEACHER EDUCATION

Albert E. Meder, Jr., Executive Director, Commission on Mathematics

In order to understand the implications of the work of the Commission on Mathematics for teacher education, it is first necessary to review briefly the principles on which the proposals of the Commission rest, and the character of the recommendations themselves.

The Commission holds that revision of the secondary school college preparatory curriculum in mathematics is necessary at the present time because mathematics itself, its applications, and its philosophy have all changed profoundly since the traditional high school curriculum took form. Of these, the most important as a criterion of secondary school curricular revision is the philosophy or point of view: no longer do mathematicians look for tricks to solve problems, but rather regard mathematics as the study of "pattern," of regularity in phenomena that the human mind can recognize. This point of view should be reflected also in school mathematics; too often at present it is not.

Moreover, the Commission is desirous of securing the introduction into as many American secondary schools as possible, as quickly as possible, of a curriculum oriented to the manifold needs of the second half of the twentieth century. To bring this about, it is essential that the proposals for revision must (a) be a modification of the traditional curriculum, rather than an outright replacement of it by new subject matter; (b) be capable of being introduced gradually, as teachers are

* Approximately 100 participants from the states of Virginia, West Virginia, Maryland, District of Columbia, New York, New Jersey, and Pennsylvania attended the conference.

able and willing to make the necessary modifications; and (c) be of such a character that teaching will be simplified, clarified and unified through their acceptance. The Commission believes that its proposals will meet these tests.

It may be added that without a change in the point of view from which instruction is given, so that the development of mathematical power is sought rather than mere manipulative skill, substitution of one body of subject matter content for another will be sterile. Moreover, a further objective of the Commission is to make it possible for colleges to teach freshmen college mathematics, not trigonometry and advanced algebra. Finally, the Commission seeks through the introduction of new concepts to bring school mathematics into closer relationship with more advanced mathematics.

Specifically, the Commission proposes that algebra be taught from a completely new point of view, as the study of mathematical structure rather than as the development of certain manipulative skills alone, that inequalities as well as equations be studied, and that deductive proof be a feature of the instruction, that geometry be restricted to one year, and include a short chain of theorems, taught with emphasis upon the nature of deductive reasoning, algebraic as well as synthetic proofs, and work in three dimensions as well as two; that trigonometry be divided into two parts, the trigonometry of angles and the trigonometry of numbers—(or, otherwise described, as computational trigonometry and analytic trigonometry, the former to be included in the eleventh year, the latter to be absorbed in a new twelfth grade course, that the separate course in deductive solid geometry be dropped, and that the course in advanced algebra be divided in two parts also, the "continuous" part and the "combinatorial" part, the former to be the nucleus of a first semester twelfth grade course in elementary analysis, centering around the function concept and including the properties of the polynomial, power, exponential, logarithmic, circular and inverse circular functions, the latter to be expanded into a second term course in Probability and Statistical Inference. An intuitive introduction to polynomial calculus is to be included in the Elementary Analysis course.

The implications for teacher education may be divided into those concerning the in-service re-education of teachers presently teaching the traditional curriculum, and those having to do with the pre-service education of teachers capable of handling the proposed curriculum.

As to the former, the Commission is planning to issue a series of pamphlets describing the knowledge a teacher should possess in each subject area of the curriculum, with specific suggestions as to where to find presentations of it. It is encouraging schools to form study

groups of teachers, and colleges and universities to provide leaders for such groups, and to establish courses and workshops. It is also possible that visual aids will be prepared. Many study groups are active at the present time.

As to pre-service education, it is clear that the traditional college major in mathematics needs substantial modification. At the very least, a prospective teacher will need courses in calculus, advanced calculus or mathematical analysis, modern abstract algebra, the foundations of geometry (including what one professor once called "the comparative anatomy of geometric theories"), and statistics. Courses in Symbolic Logic and in "Fundamental Concepts of Mathematics" would be highly desirable.

The Commission has issued a pamphlet entitled, "The Education of Secondary School Mathematics Teachers," which deals more fully with the topic of this presentation. It may be obtained (as may the other publications of the Commission) by addressing a request to the Executive Director at 425 West 117th Street, New York 27, New York.

Modern Geometry for Teachers

Bruce Meserve, Montclair State Teachers College

Geometry appears in curriculums under many guises: plane and solid, intuitive and deductive, synthetic and analytic, traditional and experimental, and so forth. This paper discusses detailed recommendations on the following matters:

1. What should be the geometric content of our secondary school program (grades 7 through 12)? What use, if any, should be made of finite geometries, noneuclidean geometries, and so forth? Disregard grade placement and look at the program as a whole. Interpret "geometric content" broadly.

2. What methods of attack upon geometric problems should be included (synthetic, analytic, vector, and so forth)? Identify several propositions which are particularly adaptable to each method recommended.

3. How and where in a student's training should the topics from solid geometry recommended in (1) be introduced? To what extent should plane and solid geometry be integrated? Alternative recommendations may be given.

4. How should the geometric content recommended in (1) be introduced and developed (a) during the next few years? (b) ideally from the point of view of the pupils?

In each case one should consider

(a) pupils who are not college bound,

(b) a minimum college preparatory program, and

(c) an enriched college-preparatory program.

Students requiring remedial elementary school work need not be considered.

We are now hoping that within the next five years we shall learn "How geometry should be introduced and developed." If we knew today, I could speak with much greater assurance to you. In the absence of such assurance we must rely upon our good judgement and the recommendations of other seriously concerned individuals and groups. Among such groups I include (1) the CEEB Commission on Mathematics, (2) the Division of Secondary Education of the State Education Department of New York, and (3) the UICSM.

My paper today, like ancient Gaul, is divided into three parts.

1. The geometry currently recommended for grades 7–12.

2. The traditional manner of preparing teachers to teach this geometry.

3. Minimal and recommended lists of topics that should be considered in undergraduate and first year graduate courses to prepare these teachers.

Any discussion of the mathematical preparation of secondary school teachers must be based upon certain assumptions regarding the content of secondary school courses. My assumptions are stated in (A) below. I also assume that no one can teach effectively unless he has progressed further than he is trying to lead his students. A brief summary of the present preparation of geometry teachers is given in (B); minimal and recommended lists of topics to be covered in the training of teachers in (C).

A. Geometry Recommended for Grades 7–12

1. Concept of a geometric figure.
2. Recognition of common plane and space figures.
3. Concept of measurement
   linear, angular, surface, volume;
   accuracy, precision, error, relative error.
4. Knowledge and application of mensuration formulas
   as individual formulas,
   as special cases of more general formulas.
5. Relationships among geometric figures
   equality, congruence, similarity, symmetry.
6. Classifications of geometric figures
   angles, triangles, quadrilaterals, common solids.
7. Constructions of geometric figures
   the role of constructions in the geometry of Euclid.
8. Geometric representations
   bar, line, circle, and so forth, graphs,
   scale drawings, indirect measurements,
   the number line for the set of real numbers,
   the coordinate plane for ordered pairs of real numbers,
   graphs of algebraic relations on a coordinate plane
      equalities and inequalities
      linear, quadratic, trigonometric, exponential, logarithmic

graphic solutions of problems, nomograms.

9. Geometry as a deductive system
   necessity of postulates,
   nature of proof,
   properties of definitions.
10. Study of invariant properties of geometric figures under congruence transformations
   measures of line segments, angles, areas, volumes,
   triangles and related figures,
   parallel and perpendicular lines,
   circles and related figures,
   regular polygons,
   planes and lines in space,
   prisms and pyramids,
   spheres, cylinders, cones
   regular polyhedra.
11. Locus problems related to properties considered above.
12. Study of invariant properties of figures under similarity transformations.
13. Coordinate plane geometry (may be introduced after the unit on quadrilaterals)
   Δx, Δy, parallel lines, perpendicular lines,
   mid-points of line segments on a coordinate plane (after it is known that if 3 or more parallel lines cut off equal segments on one transversal, they cut off equal segments on any transversal),
   distance between two points on a coordinate plane (in space) (after the Pythagorean Theorem),
   slope, locus, area.
14. Coordinates in space.

B. Traditional Preparation of Geometry Teachers

Freshman college mathematics
Calculus
College geometry
Methods course

I suggest that a definite reorientation of our point of view and probably our course content is needed it we are to prepare geometry teachers to do more than perpetuate the routines to which they were themselves subjected. At present we do reasonably well in developing skills for solving traditional problems. We must also develop appreciation and skills regarding

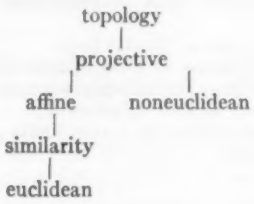
geometry as a deductive system,
algebraic solutions of geometric problems (coordinate geometry),
the place of secondary school geometry in modern geometry, in modern mathematics, and in our contemporary civilization.

C. Topics That Should Be Considered in the Training of Teachers of Secondary School Geometry. A Minimal List Is Unadorned; Starred Topics Are Highly Recommended

1. Geometric figures
   as recognized in elementary schools,
   as described in junior high schools,
   as sets of points, lines, and planes.
2. Cartesian coordinate systems
   on number line,
   on plane,

*in 3-space.

3. The extension of geometry to 3-space and higher dimensions. Include some of both synthetic and coordinate geometry of 3-space; n-spheres for $n=1, 2, 3, \cdots$.
4. A comparison of the structure of high school geometry courses; proofs of theorems in each sequence.
5. Common and advanced problems to be solved using methods of synthetic geometry, coordinate geometry, locus theorems, *vector spaces.
6. The algebraic basis for classical constructions.
7. The content and structure of secondary school geometry.
8. The use of visual aids in teaching geometry.
9. Geometry as a deductive system
   axioms, postulates, definitions, theorems,
   finite postulational systems,
   isomorphic representations.
10. The hierarchy of geometries indicated on the following array with at least the characteristic properties of each geometry mentioned. (*detailed treatment).



11. *The development of euclidean geometry from projective geometry and topology OR the generalization of euclidean geometry to obtain projective geometry and topology.
    The treatment should include both synthetic and analytic methods. There should be discussion of the dependence on the postulates used of common figures and theorems of euclidean geometry.
12. The historical evolution of our concept of geometry.
    The treatment should include early empirical procedures, the development of postulational systems, the role of artists in the development of descriptive and projective geometries, the role of algebra in the development of analytic (or coordinate) geometry, *the role of calculus in the development of differential geometry, and *the role of logic in the development of geometries as deductive systems.
13. Noneuclidean geometry
    a comparison of euclidean geometry and the geometry on a sphere, *noneuclidean geometries as postulational systems, *polarities as a basis for the "scratch equation" and the development of noneuclidean geometries from projective geometry.
14. Topology
    Jordan Curve Theorem, 4-color problem, traversable networks, Moebius strip, *detailed study of homeomorphic figures.
15. Geometry as a study of properties of figures invariant under
    a *group* of transformations.
    rigid motions, translations, rotations (point and line), *orthogonal line reflections, *matrix representation of transformations.

In conclusion I want to emphasize that I am not proposing a course structure for covering these topics. I feel that our first task is to agree on the topics and their priorities. Then we should consider the course

structure. I have been experimenting with this course structure for over a decade. In the framework of the courses at the University of Illinois, I was pleased with the organization. In the framework of the courses at MSTC, we have used a different course structure each year for the past three years. We cover the minimal list in our undergraduate courses on

college geometry (a 4s.h. required course with a modified treatment)
history of mathematics (elected by most majors)
solid geometry (required of students who did not take a course with this title in high school, elected by many others, and including both synthetic and analytic methods.)
applications of mathematics (3s.h. required with a laboratory period)
teaching of secondary school mathematics (3s.h. with an added requirement of 4 observations each week in the demonstration high school under conditions specified by the instructor).

We would like to cover some of the topics more thoroughly. Our goal is to cover at least the minimal list in our undergraduate program, to include the starred topics in our undergraduate program as time allows, certainly in our graduate program.

The Mathematical Training of Elementary School Teachers

Ben A. Sueltz, State University Teachers College,
Cortland, New York

NOTE: The basis of this paper is set forth in outline form. The speaker also discussed some of the factors in methods of teaching and learning.

I. What Generally Should an Elementary Teacher Possess?
  1. A reasonable competence in all areas of instruction
  2. A reasonable understanding of child growth and learning
  3. A reasonable background in social, cultural, home experiences
  4. A reasonable personality and human relations

II. The Mathematical Background of an Elementary School Teacher
  1. Rather good competency of elementary school mathematics
    Understanding of basic concepts, principles, operations, relationships
    Knowledge of mathematics in our society
    Understanding of role of sequence and dependencies
    Some general idea of grade placement and grade goals
    Identification of the easy to learn and the more difficult
    Extensions of arithmetic beyond elementary school content
  2. Knowledge and appreciation of mathematics as a field of study
    Algebra, principles and applications of linear equations
      The number systems enlarged and extended
      Principles of operation and computation
      Indirect measurement including Trig. ratios
      Progressions: A.P. and G.P.
      Algebraic method with certain geometric proofs
    Statistics: Concepts and use of measures of central tendency and dispersal
      Concepts associated with variability and probability
      Linear correlation
      Interpretation of test data

Geometry and Logic: Relationships of figures and their properties
Derivation of formulas for measurements
Logic of "if A then B" and "Venn diagrams"
Role of assumptions

New Mathematics for the Junior High School

M. L. Keedy, University of Maryland

The traditional 7th and 8th grade mathematics curriculum now being taught was designed as a terminal course, and therefore contains few new mathematical ideas and many social applications. The transition to 9th grade algebra is abrupt. Many believe that it is mainly in grades 7 and 8 that children develop distaste for mathematics.

The University of Maryland Mathematics Project (Jr.H.S.), financed by the Carnegie Corporation of New York, is developing courses for grades 7 and 8 which it is hoped will be mathematically and psychologically sound, for students of all abilities. Twenty-five teachers in the Washington area are participating. They assist with preparation of materials and do the experimental teaching.

The distinction between mathematics and its applications is one guiding principle in developing materials. The distinction between arithmetic and algebra is being minimized, learning for understanding rather than by rote is being emphasized, and applications are to be preceded by mathematical understanding.

Distributions

E. J. McShane, University of Virginia

The purpose of this lecture was to exhibit a recent mathematical development still in a stage of rapid growth, which nevertheless has at the same time been polished so that in part it is accessible to advanced undergraduates. For use in quantum mechanics P. A. M. Dirac introduced "ζ-functions," which had many good properties but one very bad one, namely that no such functions can possibly exist. L. Schwartz devised generalizations of the concept of function, called "distributions," which are mathematically consistent and still yield everything for which "ζ-functions" were invented. Now several mathematicians have worked out sequence methods by which distributions are built out of ordinary continuous functions in somewhat the same way that the real numbers are built out of the rational numbers. This definition was presented and used to prove some of the basic theorems about distributions.

PART II. RECOMMENDATIONS OF DISCUSSION GROUPS

I. Recommendations for Freshman and Sophomore Years in College

Leader: James J. Barron
Marshall College
Huntington, West Virginia

Recorder: Allene Archer
Maryland State
Teachers College
Towson, Maryland

1. That elementary school teachers be required to take 6 hours of college mathematics exclusive of methods courses.
2. That a student who plans to teach secondary mathematics should complete by the end of the sophomore year a minimum of 12 hours of college mathematics including 6 hours of calculus. These courses should be acceptable as a part of a major sequence in mathematics.
3. That a teacher of secondary school mathematics should have a major in mathematics.
4. That a teacher of secondary school mathematics have at least 6 hours in an allied field.
5. That departments of mathematics gradually revise their courses for the first two years in the light of recent thinking with respect to subject matter content.

II. Recommendations for Junior and Senior Years in College

Leader: Stanley B. Jackson, University of Maryland, College Park, Maryland — Recorder: I. L. Stright, State Teachers College, Indiana, Pennsylvania

Assumptions:

1. By the end of the sophomore year the student in the college will have successfully completed at least a six-hour course in differential and integral calculus.
3. The mathematics teacher whose training is under discussion is to be a teacher in a junior or senior high school which has a good, modern program in mathematics.

There was common agreement in favor of a stronger mathematics program during these years. The present offering of the colleges represented at this meeting now varies greatly both in content and extent. The discussion revealed the need of greater coordination between superintendents, teachers, administrators, certification boards, and college departments.

Recommendations

A. During the last two years of college the prospective teacher should have work in the following general areas:
   1. Analysis—this is to be in:
      a. Advanced calculus including sequences, infinite series, continuity, multiple integrals, line integrals, and so forth, and/or
      b. Differential equations.
   2. Algebra—This area may include transformation groups, rings, theory of equations, matrices, modular arithmetic, and number theory.
   3. Logic and Foundations—This area may include such topics as theory of sets; mathematical or symbolic logic; postulates for geometry, algebra and arithmetic.
   4. Statistics—Emphasis is to be on probability and statistical inference.
   5. Geometry—Could include such items as a study of geometric figures; cartesian coordinate systems; extension of geometry to 3-space and higher dimensions; common and advanced problems solved using methods of synthetic geometry, coordinate geometry, and locus theorems; the algebraic basis for classical constructions; content and structure of secondary geometry; visual aids in teaching geometry; geometry as a deductive system—axioms, postulates, definitions, theorems, finite postulational systems; characteristic properties of the geometry of topology, projective non-Euclidean, affine, Euclidean.

B. A major in mathematics shall consist of a minimum of 30 hours with 36 considered desirable, exclusive of methods courses. At least 15 hours of this work is to be beyond integral calculus and taken in the five areas mentioned in Recommendation A.

C. Students preparing to teach mathematics should complete a major in this field.
D. Since a fifth year program is becoming increasingly necessary for strengthening the teachers' background in the five areas previously mentioned, the colleges are urged to develop suitable graduate courses for this purpose.
E. For permanent certification the teacher will complete a fifth year program leading to a Master's degree. At least half of the work in this program is to be in the major field.

COMMENTS

We recognize the training of a mathematics teacher is never complete with either the Bachelor's or the Master's degree, but is a continuing process.

CLIP AND FILE

Current newspaper clippings supplement the science textbook. Pupils clip and file material for immediate use.

1. The pupil indicates the name of the daily or weekly newspaper delivered to his home. Each pupil is assigned the coverage of a paper for one day per week throughout the semester. During the week of issue the pupil clips all articles of importance for class use. The article must remain attached to the date line across the top of the paper.

2. What to clip? The headings listed for our Vertical File to date are available to each pupil in mimeographed form. A topical list changes as current news is printed in book form. Headings, such as the following appear in our current file: Algae (See also Plants)

Animals
  Adaptations
  Habits and behavior
  Use of
Atoms and Atomic Energy
Heredity
International Geophysical Year
Shelterbelts
Weather

3. The newspaper material filed makes it available for use in the science class as well as in other classes or for discussion. At the time that we are discussing Heredity we can use up-to-date items from the file. Every article on insects placed on the bulletin board was read and pupils had a short quiz or wrote five questions concerning the insects which made the news.

Over a period of six years I have tried to learn from some teacher a best method for making available items from the newspaper. During the past two years this clip and file system has made current news items a part of or supplementary to the text.

MILDRED CAMPBELL
Shortridge High School
Indianapolis 7, Indiana

STUDENT 1957—CHEMIST 1965*

J. R. Howell
Union Carbide Chemicals Company, Chicago, Illinois

It was with mixed feelings that I accepted the invitation to address you today. I am, of course, very grateful to have the opportunity to discuss a subject of such great importance to us and our country. I must confess that I have feelings of admiration and envy toward the teaching profession. I greatly admire your dedication and envy the position of the high school teacher which permits him to guide the high school student. Somehow in this brief appearance I hope that I can persuade you to devote a greater share of your dedication to the goal of larger and better and more advanced classes in chemistry, physics and other sciences at the high school level.

All of us have read of the large number of scientists and engineers being graduated from technical schools in the Soviet Union. We shrug this off by saying that these students were "selected" for scientific careers. I doubt this. Probably much emphasis on the desirability of studying science was given to the students by their teachers. They point out how science can help the motherland fulfill her dubious destiny. They explain how scientists can have a higher standard of living than the rest of the population. We can and should do the same but with other goals. These goals should include the personal satisfaction of contributing to mankind, the joy of doing challenging work, the excitement of discovering truth and, for those who teach science, the knowledge that what is taught will help others decide on a career which is rewarding in more ways than just the material.

One of my extra-curricular activities is that of recruiting college students for employment with my company. Since those I talk to are always students majoring in chemistry or chemical engineering, I make a point of asking each one of them what made them decide to enter such a field. Almost without exception, they state that they decided on such a future when taking their high school courses in chemistry. They elaborate on this by saying that their high school chemistry teachers fired their imaginations so successfully that they saw a challenging and promising future in the field of chemistry. This is why I envy all of you the opportunity that you have to influence the future of individuals and the future of this country, which will depend more and more on its scientific achievements.

You may well ask why is it necessary that you encourage promising students to study chemistry on the high school level. The answer is: We can expect a desperate shortage of chemists if present trends

* Paper presented at the Convention of The Central Association of Science and Mathematics Teachers, Chicago, Illinois, November 30, 1957.

continue. The Manufacturing Chemists Association recently found that this country will be short 457,000 scientists and engineers by 1965. Of this number, the Chemical Industry will be short 93,000. Why is such a figure significant?

Let us look at the country as a whole. The population is now 170,000,000. Only a few years back we entered World War II with a population of 135,000,000. That is an increase of 35,000,000 in 16 years or the equivalent of 4 New York Cities or 9 Chicagos. By 1975 our population will reach 228,000,000 or an increase over today of of 58,000,000. This is a huge challenge to our industrial machine. The Chemical Industry certainly cannot improve or even maintain our present level of living if it is short 93,000 chemists in 1965.

With the great *opportunity* you have to start young people on a career of chemistry you also have an even greater *responsibility*. I would like to develop and explain what I feel is your "responsibility" as science teachers.

The Chemical Industry has large responsibilities in our growing economy. In the field of shelter, for example, it must produce new fibers, paints, sheeting, building materials and a thousand other products which go into the modern home. The industry has always been aware of its responsibility to make an ample supply of such products but also make them cheaper, better and safer. Paints, for instance, are now easily applied from a water emulsion. Disagreeable odors are gone, the paints dry rapidly and are nonflammable.

In the field of health, the Chemical Industry has assumed great responsibility in helping the pharmaceutical industry produce new, more and better drugs. In years to come, drugs which will aid in the maintenance of health and the prevention of disease in the field of geriatrics will become increasingly important. Tranquilizing drugs have already accomplished much in the field of mental health. Chemical and drug research has the goal of producing drugs which will reduce the number of mental patients who now occupy one-half the beds in our hospitals. It is the Chemical Industry's responsibility not only to develop new and more effective drugs but also to make certain that they are properly used and administered.

A third area of responsibility of the Industry is agricultural chemicals in the form of fertilizers, herbicides, insecticides, fungicides and others that are playing a big part in producing safe and nutritious food in larger quantities. This responsibility is of increasing importance as the total population increases while the farm population decreases. It is generally recognized that the efficiency of farm land be continually improved in order to prevent food shortages in this country.

There are many other areas where the Chemical Industry shoulders

responsibilities—the field of power, where nuclear and solar energy will play a major role; the field of communications, in which Argon gas, epoxy resins and numerous other chemical products are important; the field of transportation, where synthetic lubricants, polyurethane foams and improved fuels are but a few of the products now being developed and growing in use.

In the vital field of guided and ballistic missiles and concomitant earth satellites the Chemical Industry has responsibilities which are extremely important. In the light of recent developments, one might reasonably inquire has the industry fallen short in this field? The answer is "yes" or "no" depending on how you look at the factors of timing, world propaganda and scientific results. Missile and satellite programming before Sputnik I were not crash in the sense of the Manhattan project. One might say, with little justification, that it should have been the responsibility of the industry to make missile development a crash program. Looked at realistically, such a program could not be carried out by private industry. The costs involved and the secrecy necessary limit such an undertaking to the government. I believe that the Chemical Industry has cooperated completely in this government project.

Leaving aside these matters of opinion let us look at the present responsibility of the Chemical Industry to the outer space problem. This responsibility is and will continue to be critical both from the military and non-military aspects.

We are now entering a new age. This is an age where we are truly entering the unknown as surely as did Columbus. Those students who choose the field of chemistry will be the pioneers who will help gain the basic knowledge which will lead us to other planets and possibly to other solar systems. Your responsibility is to light the spark which will fire some students toward this line of intellectual achievement.

I hope, at this time, that you have no doubts that the Chemical Industry as an Industry has assumed major responsibility in the continuing growth of much of the Nation's industry and the results of its output. However, the industry cannot effectively continue to carry this responsibility unless teachers take the responsibility of pointing a larger number of high school students towards Chemistry, Physics and other sciences.

You teachers have a basic responsibility for the future—the responsibility of providing competent successors. This is the responsibility of providing a sufficient number of qualified people to run the industrial machine and the high schools and colleges of tomorrow. It is up to you to do your utmost to cut that 1965 figure from a shortage of 93,000 to as close to zero as possible. Thus your responsibility and opportunity is the greatest of all for you deal directly with

minds which are not yet set on a definite career. You can and should try to influence those minds for a career which offers such extraordinary opportunities for service to mankind. Nothing could be more rewarding to you and your students. You are in the best possible position to aid your students in becoming the chemists of 1965. In the broadest sense, you are in the position for fulfilling the destiny of your country and the entire world.

SCHOOL SCIENCE AND MATHEMATICS PROBLEM DEPARTMENT—1957

CHARLES W. TRIGG

Los Angeles City College, Los Angeles, California

Under the able editorship of Dr. Margaret F. Willerding of San Diego State College the SCHOOL SCIENCE AND MATHEMATICS Problem Department offered 54 challenge problems for solution during the year 1957. These were distributed as follows: 7 algebra, 13 plane synthetic geometry, 4 solid geometry, 5 analytic geometry, 6 trigonometry, 5 physics, 2 calculus (limits), 2 series, 3 complex variable, 4 number properties, and 3 miscellaneous.

Ninety-seven persons contributed a total of 291 solutions and proposals to the department. Of these 61 made a single contribution, the others more in varying degree. The five most prolific contributors were: A. R. Haynes, Tacoma, Washington (29 contributions), C. W. Trigg (25), Brother Felix John (18), Cecil B. Read (16), and W. R. Talbot (15). Seventeen of the contributors were students, each from a different school. One of these, Robert A. Morris of Philadelphia, solved 6 problems.

The contributors were widely distributed—Australia, Canada, Columbia, England, India, and 27 of the United States being represented. The greatest concentrations were in New York with 18, including 8 students, and California with 13.

SUPERHIGHWAY-MONORAIL SYSTEM MAY CARRY FUTURE TRAVELERS

Traveling straight "as the crow flies" may be a reality in the year 2000.

A superhighway-monorail transportation core, designed by General Motors Corporation engineers, was described by GM president Harlow H. Curtice. The transportation system is already in model form, he said, ready for display at the Brussels World's Fair which opened April 17.

Three levels, set between pairs of pillars, will carry electronically guided automobiles and a two-way monorail commuter train system. The two top levels are three-lane electronic highways, one for carrying traffic in each direction. The monorail train system is suspended below the lower highway.

"The elevated transportation core would allow inter-city passengers to travel in a straight line with maximum speed and safety plus unparalleled vision," Mr. Curtice pointed out. "In addition, it would free valuable land below the highways and monorail for farming, housing and industrial use."

The three-level system would eliminate the curves and hills in present-day highways. In areas where land is scarce or where dense populations make it difficult to free surface land for highway use, the prospective system would be particularly valuable, Mr. Curtice said. "Cost factors" would have to be resolved, however.

The operating model of the superhighway-monorail system that was shown at the Brussels Fair is part of a 15,000-square-foot exhibit on past, present and future highway transportation. Also included will be driver training cars and an exhibit showing how modern highways are built.

ON THE USE OF DIFFERENCE EQUATIONS IN BEHAVIORAL DIFFUSION THEORY

HENRY WINTHROP
University of Wichita, Wichita, Kansas

In a recent note to this JOURNAL, Goldberg (1) has pointed out the ease with which a certain type of cumulative growth function, used in behavioral diffusion theory, can be obtained by the application of difference equation methods. This was done by applying difference equations methods to a formula developed by the present writer in a paper submitted to this JOURNAL (2). In this connection I should like to point out that (a) the formula worked out by Goldberg had actually already been developed previously by the present writer in a monograph which has not as yet been published (3) and (b) the use of the more laborious formula used by the present writer arose out of a need to achieve *consistency* with the rest of the present writer's theoretical work in diffusion theory. Since Goldberg was unacquainted with this theoretical context and since that context is of such a nature that it may place some restriction on the extent to which additional simplifying expressions may be obtainable by difference equation methods, I should like to describe that context briefly. Before doing so, however, I should like to present my own derivation of equation (4) of (1), which was transmitted to Goldberg before the appearance of his note.

If we make use of the identity, $\phi(t) \equiv m_t$, and if we refer to (1), we find that we have

$$N(1) = (m_1 + 1) = Y_1 \qquad 1(a)$$

$$N(2) = N(1)m_2 + N(1) \qquad 1(b)$$

$$= N(1)(m_2 + 1) \qquad 1(c)$$

$$= Y_1 Y_2 \qquad 1(d)$$

so that in general

$$N(k) = \prod_{j=1}^{k} Y_j. \qquad (2)$$

If we then let $Y_t = \phi(t) + 1$, we have

$$\prod_{j=1}^{k} Y_j = [\phi(k) + 1]! \qquad (3)$$

which is identical with (4) of (1). If $\phi(t)$ is a constant we obtain clearly enough formula A' of (2), while if $\phi(t) = t$, we obtain $N(t) = (t+1)!$

It should be pointed out, however, that the derivation of equation (3) depends precisely upon the fact that the *sociality* function, $\phi(t)$, is *assumed identical for all transmitters* in time. However, many of the models used in diffusion theory by the present writer involve complications to which the simplification employed above, will be, I believe, inapplicable, although possibly other simplifications may be developed. Let me give one instance of what I mean.

Suppose $\phi(t)$ is a *phase function* which measures the *varying intensity of interest* displayed by any transmitter in spreading a rumor. If this phase function is common to all transmitters then, in a sense, each transmitter operates in a *private time* which is embedded in *public, calendar time*. By private time we mean that in general different transmitters who are at phase, $\phi(i)$, may be at that phase for different values of t and that in general for any given value of t different transmitters may be operating psychologically at different phases of $\phi(t)$. If this is one of the underlying psychological conditions of diffusion, then the variable increments of behavioral diffusion will be represented by the following model, where Δ_i represents the increment to diffusion at $t=i$.

$$\begin{aligned}
&\Delta_0 = 1 \\
&\Delta_1 = \phi(1) \\
&\Delta_2 = \phi(2) + \phi(1)\phi(2) \\
&\Delta_3 = \phi(3) + 2\phi(1)\phi(2) + \phi^3(1) \\
&\vdots \\
&\Delta_i = F(h_i, \phi)
\end{aligned} \tag{4}$$

in which $F(h_i, \phi)$ designates the partitions of the integer, i, and in which the coefficient of each partition represents the number of possible permutations of that partition. I believe that the introduction of the *general* type of simplification used by Goldberg and myself, would not be possible in this model. If, however, we assume specific expressions for $\phi(t)$, this model will generate some well-known series so that the absence of any general difference equation expression works no hardship. If, for instance, we assume $\phi(t) = t$, the model will generate the *alternate* terms of the Fibonacci series

$$1+2+3+5+8+13+21 \cdots.$$

If we assume $\phi(t) = kt$, the model which will then be generated for the schema represented by equation (4) is the following.

$$\Delta_0 = 1$$

$$\Delta_1 = k$$

$$\begin{aligned}
\Delta_2 &= 2k\gamma + k^2 \\
\Delta_3 &= 3k + 4k^2 + k^3 \\
\Delta_4 &= 4k + 10k^2 + 6k^3 + k^4 \\
\Delta_5 &= 5k + 20k^2 + 21k^3 + 8k^4 + k^5 \\
&\vdots \\
\Delta_i &= ik + \frac{[(i-1)+2]!k^2}{(i-2)!3!} + \frac{[(i-2)+4]!k^3}{(i-3)!5!} + \frac{[(i-3)+6]!k^4}{(i-4)!7!} \\
&\quad + \cdots + \frac{[i-(n-1)+2(n-1)]!k^n}{(i-n)!(2n-1)!} + \cdots + \frac{k^i}{(i-n)!(2n-1)!}
\end{aligned} \tag{5}$$

where the coefficient of k^n is the n-th term of the $2r$-th order of the figurate numbers and where the n-th term of the r-th order of figurate numbers is given by

$$\frac{(n+r-2)!}{(n-1)!(r-1)!}.$$

In terms of i, however, the coefficient of k^n is the $[i-(n-1)]$-th term of the $2n$-th order of the figurate numbers.

From the preceding it should also be clear that $N(t)$ is a polynomial of the following form.

$$N(t) = kS_t^2 + k^2S^4_{t-1} + k^3S^6_{t-2} + \cdots + k^tS^{2r}_{t-(r-1)} + 1 \qquad r = 1, 2, \cdots n \tag{6}$$

$N(t)$ may be evaluated by noting that the sum of n terms of the r-th order is

$$\frac{n(n+1)(n+2)\cdots(n+r-1)}{r!}$$

which is the n-th term of the $(r+1)$-th order. In equation (6) above $S^{2r}_{t-(r-1)}$ is the sum of the first $t-(r-1)$ terms of the $2r$-th order of the figurate numbers. This expression for $N(t)$ is, of course, obtained by aligning all the polynomials of the form represented by equation (5) and adding our results vertically.

The preceding consideration, I believe, makes clear the limitations upon the generalization introduced by Goldberg and myself and, at the same time, indicates that to some extent the absence of a general expression derivable from difference equation methods, may be no barrier to a general, mathematical analysis.

In order to make diffusion theory models of the type in which the present writer is interested, approximate socio-psychological realities, it has been necessary to introduce into diffusion theory dozens of

psychological and sociological parameters which result in formulae sometimes too complex to allow for the easy simplification which Goldberg has emphasized. I might mention only three of these complications here. One concerns the nature of $\phi(t)$, that is, whether $\phi(t)$ is a private or a public time function, or both. A second complication has to do with the question of whether transmitters experience repetitious contacts or not and, if they do, what type of repetitious contact occurs, since it can be shown in diffusion theory that repetitions are classifiable into *at least four* species. A third complication has to do with the effect upon the rate and manner of diffusion of the *acquaintance structure* of the transmitting population. By the acquaintance structure of a population we refer to a parameter which measures the *degree of amicability*, I, of the diffusing population as a whole. We define I as follows. If the *average size* of any transmitter's *circle of acquaintances* is D, and if r represents the *number of pairs* of these D acquaintances who are also acquainted with each other, then

$$I=(D+r)\Big/\binom{D+1}{2} \tag{7}$$

$$=2(D+r)/D(D+1) \tag{8}$$

where $1\geq I\geq 2/(D+1)$.

If two of the complications mentioned, namely, the type of sociality function (there are three of these) and the type of acquaintance structure (there are also three of these of which one is a variable while the other two are not), are combined with a third condition, namely, the presence or absence of repetitious contacts, one can obtain 18 *basic or nuclear* models of diffusion. Few of these will lend themselves to the difference equation simplification that occurs when $\phi(t)$ is common to all transmitters and is a public time function. If these nuclear models are highly revamped to account for many interacting psychological and sociological realities, through the introduction of additional parameters, the use of difference equation simplification is made even more difficult.

I have tried to point out here that the type of difference simplification introduced by Goldberg and myself, is sound and proper. Whether that type or more sophisticated types which may subsequently be developed, will be applicable to some of the other finite difference models of diffusion theory, remains to be seen. Goldberg has the original volume (4) in which my diffusion theory first appeared, in his hands at present. If he succeeds in developing additional types of simplification for other diffusion models, he will no doubt bring these either to the attention of the present writer or to that of interested readers of this JOURNAL.

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INERT GAS SUCCESSFULLY DETECTS HEART "SHUNTS"

A radioactive form of a harmless inert gas, krypton-85, is now being used to detect abnormal openings in the wall of muscle dividing the right and left chambers of the heart.

The abnormal openings, or "shunts," result from defects in the partitions of the heart and are the commonest form of congenital heart disease. Accurate knowledge of the presence and location of these defects is essential for corrective surgery.

SCIENTIFIC ACHIEVEMENTS AND SCIENTISTS I SHOULD KNOW

Pupils enrolled in a science course should know the names, dates and accomplishments of men and women who have made scientific contributions.

First, each pupil is assigned or chooses a different scientist. He writes a short biographical sketch including year of birth and death (if deceased), birthplace and country where work was done on accomplishment in a scientific field. This sketch is placed on a bulletin board in the room.

Second, the pupil reads and charts the important facts given in the life stories written about the scientists chosen.

> Name of Scientist—Dates—Birthplace—Country in which work was done —Scientific contributions

Every pupil with his chart before him places the scientist on a date line. 500 to B.C.—A.D. 100, 200, 300—to the present time 1850, 1900, 1950.

When did most of the scientists live and work? What is the reason for the increase in scientific achievements during certain periods in history? One soon realizes that regardless of the country of birth or the country in which the scientist was allowed to continue his work his contributions belong to the world.

This entire assignment of introducing pupils to scientists takes about 2 or 3 days at the most. Any pupil desiring to continue with the assignment can do so. Nobel prize winners are listed in the Almanac. Other books are available such as—*Current Biography*, *Who's Who*, *Men of Science*, Encyclopedias, textbooks and magazines. I believe that pupils should know the men and women in the U.S.A. as well as worldwide who have made special scientific contributions in the field of disease, health, conservation, explorations, genetics and other scientific fields.

Mildred Campbell
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TEACHING THE MAJOR CONCEPTS OF RELATIVITY

A REPORT OF THE JOINT SYMPOSIUM OF THE TEACHING SOCIETIES OF THE AAAS AT 9:00 A.M. BALLROOM OF THE HOTEL ANTLERS, INDIANAPOLIS, INDIANA, SATURDAY, DECEMBER 28, 1957

GEORGE G. MALLINSON, *Chairman*

As every science teacher knows, the subject matter of science is expanding at a fantastic rate. Much of this subject matter is constantly impinging on the high-school student through the media of mass communication. Thus, many of these knowledges affect science education in the public school.

In recognition of these facts the symposium described above sought to find ways in which relativity may be taught in the public schools. The keynote presentation by E. J. Konopinski is followed by suggestions for implementing the points contained therein.

TEACHING THE RELATIVISTIC CONCEPTS

E. J. KONOPINSKI
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What I say here ought to be drawn from my own experiences with the teaching of relativity. From those, I might have gleaned helpful tips about the astonishing number of ways in which students can misunderstand what one tries to tell them about relativity. However, it is doubtful that my particular tips would have very general interest; my experiences have been too much limited to specialized, graduate students of physics. Bringing this up only serves to remind us that different students must be approached differently; and this fact is itself an illustration of one of the most important lessons to be learned from the development of the relativistic ideas!

This first lesson which I bring up is: what we *mean* by a concept lies in what we *do* with it; significance is in *action*, not *words;* the best way to nurture understanding of any physical concept is to show how it is to be *applied*, in the processes of thought and deduction.

Graduate students are prepared to apply the relativistic concepts, and in their least ambiguous, pristine form. That form is expressed in mathematical language, sufficiently precise to enforce consistency in the applications. When the mathematics must be translated into English, as for less developed students, then one is forced to rely on a comparatively crude instrument of communication for the purpose. Non-mathematical language is scarcely capable of expressing the

real, *working* significance of most physical concepts, and especially the relativistic ones.

Does this mean that mathematically illiterate people should be fobbed off by being told that relativity is beyond their understanding? That, to my mind, is even worse than translation into "pidgin English." But I do feel strongly that people should be aware of how much they *miss*, by not being at home with mathematics as a language. It is just this which makes it imperative for youngsters interested in science to gain fluency in mathematics first.

I find myself apparently advocating the teaching of relativistic concepts by teaching mathematics, instead. Actually, much could be said for just that. Mathematical language is such an economical mode of expression, it enables so much more rapid a grasping of physical principles, that the latter may readily wait. Learning mathematics cannot wait. Learning any language must begin early if permanent bad habits, in the precision of expression and thought, are to be avoided.

On the other hand, the rigors of learning any language, mathematics included, can be a dreary business. The wide berth given such training, at least by the self-indulging part of our school population, testifies to that.

Because the training is, and should be, rigorous, the student must be provided with inspiration. He must be given some glimpse, however fragmentary it may have to be, of what awaits him: those grand conceptions of nature like relativity; the joy and excitement, that comes from grasping the concepts as tools, for thinking and for discovery. We must, after all, teach natural science itself, as well as the mathematical language needed for its adequate description.

There is another compelling reason for not letting the emphasis on mathematics be too exclusive. Too many of our students gain the entirely fallacious notion that mathematics, by itself, can reveal the secrets of nature. One of the chief things our advanced physics students find themselves compelled to *un*learn is that more fact can be drawn from mathematical manipulation than was already implicit in the initial assumptions; that the mathematics of science is anything more than a language, a system of logic. Mathematics has its own great conceptions, and has unmatchable power for uncovering the unconscious implications of one's assumptions, yet the results are only as good as the assumptions were to start with.

Here, indeed, we have a second great lesson from relativity. Before the new relativistic ideas began to develop, Euclidean geometry seemed the only possible kind of geometry, and it was considered to provide unescapable facts about nature. Mathematics seemed to be telling us what the world is like.

Now we know better. The mathematicians discovered that they could construct any number of purely mathematical systems of geometry. Einstein showed that the Euclidean geometry is poorer than some others for describing nature.

The words of that last statement had to be chosen with care. It is a juncture at which some of those misunderstandings by students, which I mentioned earlier, seem to arise. Pure Euclidean geometry actually can be used for an accurate description of nature. It is only that one must make up for its shortcomings, as a geometry, by postulating the existence of forces, like gravitation. The situation here parallels that in the old solar-system problem: we *can* say that the earth, not the sun, stands still; but then we must also say that our fellow-planets travel in complicated "epicycles," instead of simple ellipses. It my car hits a parked vehicle, while I travel at 70 miles per hour, I *can* claim that it was I who was standing still—but will I be able to convince the judge?

Thus, relativistic ideas teach us that the kind of world we live in cannot be deduced from pure mathematics. Hypotheses suggested by experience of nature must be fed into the mathematical machinery, before results comparable to observations can emerge. This brings us to a better-balanced conclusion about the teaching of any science: mathematical training must be emphasized in order to give the budding scientist the tools he badly needs; but for his inspiration and understanding he must be given vital scientific examples to practice on. The best compromise seems to be for mathematics teachers to draw heavily on natural science for examples, and for physics teachers to express every possible step in at least a rudimentary mathematical form.

Relativity can supply many fine examples for an elementary mathematics course. The algebra of $\sqrt{1-v^2/c^2}$, for instance, has many fascinating facets. You can with fairly simple arithmetic show how adding a speed of 186,000 miles-a-second to 186,000 miles-a-second gives a result of 186,000 miles-a-second. You can demonstrate why muons travelling at high speeds are found to live much longer than muons at rest. Such algebra also can show why only particles which disappear when you try to bring them to rest, like the photons of light, can travel with exactly the velocity of light.

Of course, teaching of the kind I suggest requires science teachers who know some mathematics, and mathematics teachers who know some science. Fortunately, it is considered almost unthinkable, in typical universities like ours, for physics majors not to undergo nearly as much mathematics training as do mathematics majors.

The mathematicians in our physics courses are distinctly scarcer. There is a human but deplorable tendency for the mathematicians to keep themselves "pure." This behavior seems to me inconsistent

with the greatest mathematical discovery of the last century: that mathematics is "empty," in the logical sense; that its absolute validity and compelling power stem from just that emptiness. Mathematics is at bottom a language, a system of logic, which requires material from science to give it substance. That is why I view with misgivings certain developments welcomed by *Time Magazine* in recent months; the reports tell of mathematics teachers who are substituting discussion of higher and purer mathematical concepts, for drill in applications of mathematics. This seems to me an entirely wrong direction: concentrating on the grammar, rather than a conversant fluency in the mathematical language. It certainly violates the relativistic principle that concepts gain their meaning from usage.

Narrowing the training to pure mathematics is a disservice not only to the general student, but even to the future mathematician. He must not be cut off from the greatest source of fresh mathematical conceptions, the struggle to formulate the continuing findings of science. He should be allowed to see mathematics in its broadest function, as the universal language of all the sciences.

I am convinced that the mathematics teachers themselves would prefer showing off the full scope and power of their discipline by examples from science, once they learn enough of modern science to avoid the dullest examples.

My discussion so far has perhaps dwelt too much on generalities about teaching, instead of getting at the real meat of *what* to teach about relativity. Nevertheless, those were the things that seemed to me most in need of repetition, at this time of crisis in our teaching. Besides, they did provide an opportunity for pointing out the pervasive influence of relativistic ideas, in even so unscientific a field as teaching.

Finding something fresh to say about relativity, itself, is not easy. For many years now, numerous books have been available, at many levels of sophistication, which expound the relativistic ideas with ingenuity and clarity.

I doubt, for instance, that there would be much profit in my starting to talk about observers sitting on platforms, passing each other at high speeds, and exchanging information by flashing lights (meanwhile considering each other to be freakishly thin, and lazy of action). Perhaps I should mention why so many writers on relativity resort to such pictures. They simply want to strip down to essentials, the processes of measurement which give the real working significance to our concepts of space and time. It is from analyses like these that there emerges that first lesson of relativity I quoted earlier: That the meaning of our conceptions is determined by what we do, rather than what we say.

To be noticed is that almost invariably there is reference to *ob-*

servers, in relativistic considerations. For instance, we say that two events, which are simultaneous to one *observer*, to another may seem to occur at very different times, and with equal validity. Such insistence on the role of the observer is an important characteristic of the relativistic point of view.

Before Einstein, physical events were described as they would appear to some aloof, all-seeing god—as if our methods of observation had no influence on our conclusions. This notion was demolished by Einstein, with profound effects on the development of physics ever since. The most spectacularly successful and fertile development has of course been the quantum mechanics—and the essential characteristic of this discipline is that it probes even more deeply into the role of the observer than does relativity. But it was in relativity, that the first breakthrough was made to that point of view. One can say that relativity takes into account the effect on our observations of the fact that light goes at the same definite speed relative to anyone; it runs away from you at 186,000 miles-a-second even if you chase after it at 185,999 miles-a-second. On the other hand, the quantum mechanics takes into account the fact that the light you use for observing objects must bounce off those objects, and they may recoil to some place else just when you think you have located them.

It is frequently forgotten that there was a well-developed theory of relativity long before Einstein. It had long been known that when there is a relative motion of two bodies, either one can be considered to be at rest, with equal validity. Einstein's contribution was to show that such relativity had to be adhered to universally, even in the face of very peculiar consequences, like the relativity of simultaneity which I have already mentioned. The peculiar phenomena no longer seem peculiar when you consider the role of the observer, and that he has to work with causative influences restricted to the finite speed of light. Moreover, the peculiarities are noticeable only when we deal with unaccustomed speeds, an appreciable fraction of the speed of light. For ordinary speeds the new relativity is nowise different from the old; velocities add up in the ordinary way as long as they are far from pressing on their limiting value, the speed of light.

The unaccustomed speeds close to that of light are no longer so rare in modern laboratories; electrons, protons and other particles are speeded up this much as a matter of course, in our high-energy accelerators. The peculiar resistance that must develop as the limiting speed is approached, takes the form of a greater and greater *inertia* of the particles, a growth of their masses. The mass concept too is determined by its function in experiment! Now it is something that grows with the energy of the particle; one is converting energy into mass. The converse can be brought about too, the conversion of mass into

energy, as we all have well advertised reasons to know. Here relativity brings a greater unity to physics, demonstrating the interchangeability of the mass and energy concepts.

The unifications of physical concepts forced by relativity extend throughout physics, not only in mechanics. For example, what is a static electric field to one observer, becomes partially a magnetic field to an observer in motion relative to the electric charge sources. Naturally, magnetism must be observable if it is valid to consider the charges as moving. Thus magnetism becomes a kind of "relativistic correction" to electricity; just another aspect of the same concept.

I have by now managed to mention:
1) The role of measurement in determining conception:
2) The role of the observer in what is measured;
3) The role of the finite and constant light velocity, in making some phenomena seem peculiar;
4) The fact that all the peculiarities disappear at low, ordinary speeds;
5) The role of relativistic ideas in the development and unification of modern physics.

These, I think, are at least some of the broadest aspects of relativity, toward the illustration of which any concrete examples used by teachers should be directed.

So far I have left out any mention of the so-called "fourth dimension." Its explicit mention *can* be left out in relativistic considerations, and I am tempted to do so in view of the mystical nonsense there tends to gather about this conception. Actually, a fourth dimension, and fifth, and a seventeenth, are old stuff in physics. Whenever we have a situation involving n independent variables, we are free to conceive a space of n dimensions. Relativity itself teaches us that any space we conceive is merely a convenient frame in which to order phenomena. When we make a graph of stock prices against the month of the year, we are creating for ourselves a convenient space of two dimensions. It is similarly convenient, for relativistic considerations, to think of a space of four dimensions, with a time axis grafted onto the usual three space axes. This means little more than that it is convenient to compare events at different times as well as different places when thinking relativistically. You travel in the fourth dimension by merely living. This may seem disappointingly prosaic, but it is truer than many popular discussions of space-time.

In this short discussion, I have tried to point out the features common to all relativistic considerations rather than having risked giving too narrow a view by dwelling on some detailed examples. I judged that what may be bothering teachers most is not the detailed examples but their place in the whole design of relativity.

THE TEACHING OF THE CONCEPTS OF RELATIVITY

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While the attainment of a more-or-less full understanding of certain important physical principles should be one of our goals in science teaching, and while a mathematical background is often necessary for such understanding, we can, I think, teach certain aspects of relativity in our advanced classes in secondary school science with the background of preparation presently available. I believe that an acquaintance, albeit brief, with certain of the generalizations of relativity, provided the student is not misled, can be more worthwhile than a thorough knowledge of some of the dull, uninteresting material now taught. Learning in science should be exhilarating and invoke imagination on the part of the student. In relativity theory we find a new point of view, certain intriguing concepts which both interest the student and give a better understanding of the world picture.

Dr. Konopinski has mentioned some of the broad aspects that ought to be presented. Perhaps a few specific examples might now be in order. One such might well be the familiar relation, $E=mc^2$, which ought to be considered in high-school physics in conjunction with conservation of matter and energy, not left to the last days of the course as a kind of appendage. In this connection it is very intriguing to discuss the increase of gravitational mass of a spring as it is compressed or of a piece of metal as it is heated. It is to be expected too that the objects would not accelerate as much when a force is supplied, their inertial mass increasing as internal energy is increased. The implications of $E=mc^2$ should of course be considered also when discussing the sun as a source of heat or the nucleus as a source of power.

Another topic which might be discussed is the bending of a ray of light from a distant star as the light passes near the sun on its way to the earth. If the class has studied the meaning of frequency of light, using a grating in the laboratory, and understands the concept implied by the word photon, one could suggest to the students that the photon energy, $h\nu$, might be equated to mc^2, explaining that m can represent the mass achieved if the photon is converted to mass. If we think of the massive sun as attracting this mass, we can obtain an acceptance of this rather curious effect.

It also seems not unreasonable to try to explain the advance of the perihelion of Mercury to those physics classes or advanced students who study planetary motion. It is well known that the planets revolve about the sun in ellipses and that the major axis of Mercury advances 574 seconds of arc per century. While they cannot carry out the rea-

soning involved, students will no doubt accept the statement that 532 seconds can be accounted for by the effects of other planets. As for the remaining 42 seconds, it is possible to explain that during its elliptical path Mercury comes close to the sun and, according to Kepler, increases its speed when near the point of closest approach. The increase in speed results in a small increase in mass, which in turn causes greater gravitational attraction and a shift in the axis of the orbit.

What I have been saying is that the appropriate truths of relativity ought to be introduced at natural points of departure and not occupy a chapter of their own. Relative motion can be taken up with the traditional discussion of velocity, for example, and change of mass with change in velocity when, as in some physics classes, particle accelerators are discussed in simple terms.

Moreover, relativity furnishes a good opportunity to discuss scientific procedures. The Fitzgerald-Lorentz contraction is a splendid example of a working hypothesis. The extension of Newtonian mechanics by relativity theory shows how theories may have limited use and, as time goes on, either find a restricted use, or are enlarged upon, or, in some cases, die and are discarded.

The danger in all this is that we teach by dogma. But the opening of the mind to new vistas is worth the risk.

RELATIVITY IN HIGH SCHOOL PHYSICS

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There can be little doubt that a new approach to the teaching of physics in the secondary schools is needed today. The progress made in the field in the past years has changed the outlook of the physicist and this should be reflected in the high school course. Modern man, whether he realizes it or not lives intimately with science and as a consequence should have an appreciation of its workings.

High school students read science fiction; magazine articles that popularize science; newspaper articles; booklets and pamphlets published by industry: and they watch TV, all of which tends to stimulate their imagination. Young minds are quick to grasp ideas perhaps because they are not prejudiced or set. They tend to think about the things that they read and put them in their proper order in the science they are studying. It becomes our duty to see that they are properly oriented, but at the same time not stifled in their ambition to get a clear concept. This indicates that our courses must keep pace with modern ideas.

If we look at our present high school physics' text books we find that they are large and long and do present many more topics than can be discussed in a year of study. As new ideas were developed, sections were appended to the text making it longer and longer. Somehow some of the newer ideas were not incorporated into the body of the text books but added as extra sections. Some unifying thread should be used to bring the material into a little sharper focus.

A start must be made somewhere with the high school student, and as a result we teach the five units of mechanics, heat, sound, light and electricity. It has been said that if we can do a good job of teaching the basic units and give the student a good idea of the methods of science, we have accomplished our purpose. However, there are places where we can point out some of the advanced ideas and stimulate the imagination of the students so that they will want to know more and more about the world in which they live.

Teenagers are impressed by very large and very small things. For example, they like to compare the velocity of the automobile in miles per hour to the corresponding feet per second. The flight of the jet plane at velocities greater than 1100 feet per second seems very large to them. But have them compare the velocity of sound to the velocity of light and they are truly amazed. The idea of a light year never ceases to impress them once they have taken the trouble to compute the distance light travels in one year. At this point the question is sure to arise as to what would happen if it were possible to travel at the velocity of light, or if it is possible to travel at velocities greater than that of light. A question like this gives us an opportunity to investigate time, space, and matter.

With the increase in the speed of our air travel, we can ask questions such as, "what would happen to time if a jet pilot were to fly an airplane at the speed of the rotating earth?" From this type of question we can point out that out clocks and watches do not show an absolute time but only the relative time of the locality to which they are adjusted.

It would be possible to travel into space and time by visiting an observatory. Here we can have the astronomer point a telescope at a given star and be told that the one we have chosen is 110 light years away, which would mean that it takes 110 years for the light to reach the earth. It is obvious that the star is not in the position where we see it and may not now exist; and so to look into space is to look into different periods of history of the universe.

Perhaps we should take time to point out to our pupils that changes come about when velocities increase: and if the velocity increases to the speed of light, masses increase to the value of infinity, and the

diameter in the plane of movement diminishes to zero. It would not be a waste of time and may stimulate some to do more reading and investigating.

We would not lose the interest of the student and at the same time, we would have incorporated some of the material that has been appended.

It may also be of value to the high school teacher to watch the results of the Physical Science Study Committee and assist in any manner that he can to present physics as a logical and integrated whole.

RELATIVITY FOR HIGH SCHOOL

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It would be absurd to claim that Relativity can be taught to high school students of mathematics, but it would be equally blind to say that there are no concepts, methods, or sidelights of Relativity that can be brought to the high school level. There are many high school students with imagination who are capable of comprehending some of the basic philosophical aspects of Relativity and who can appreciate and use some of the general mathematical methods employed.

Perhaps the most inviting field is that of the geometry of space. High school students generally are exposed to courses in Euclidean Geometry, plane and solid. Sometimes the geometry is integrated with other areas of mathematics in the curriculum but usually the geometry course is distinct. The good teacher of geometry under either system will present this subject as *a* geometry, not *the* geometry. They will make it clear that certain assumptions are made and that at least one of these, the parallel postulate, is open to serious challenge. The teacher of geometry can then discuss the two principal alternatives to the Fifth Postulate of Euclid and point out the general nature of the spaces that devolve from these non-euclidean assumptions. The sum of the angles of a triangle may be greater than, equal to, or less than 180° is an example that can be exploited. Certain imaginative students will usually seek to explore these other geometries and the implications they have for the possible structure of the universe. The teacher can refer them to any one of a number of books written by reputable scientists who have directed their explanations on this topic to the intelligent layman. Also, college textbooks on non-euclidean geometries should be made available in the school library for reference.

The concept of shortest distance between two points offers a possibility for bringing in another idea that is basic to Relativity. The

famous experiment to observe, during a solar eclipse, the apparent shifting of the position of a star when the light from it passes near to the sun is readily understood. The explanation that space is deformed by the presence of matter is more mystifying. The concept of shortest distance then becomes related to shortest time and the interrelationship of time and the other three dimensions becomes not only plausible but necessary. In solid geometry the theorem concerning the shortest distance between two points on the surface of a sphere, as approximated by the earth, can be used as an illustration that shortest distance is really shortest time "as the crow flies."

In the area of algebra the concept of functional relations is of paramount importance. Relativity is a mathematical structure which asserts that certain variables are related in a particular manner. Students of high school algebra can learn no more important mathematical concept than that of function and its value is not limited to Relativity or even science, but extends to virtually all applications of mathematics. In the investigations of various functions, especially in advanced high school mathematics, it would be opportune to study the simpler relationships of Relativity, the most obvious of which is $E=mc^2$. The teacher can digress from a strictly mathematical analysis to point out the significance of the formula in terms of atomic power.

Since functions of many kinds will be studied as an integral part of algebra, it is suggested that the Lorentz transformation be considered along with the more common functions. For objects in relative motion a coordinate system for each may be defined. If one system has x, y, z, and t as the coordinate axes, where x, y, and z are the usual three dimensions of space and t is time, then the other system would have x', y', z' and t' as the four corresponding dimensions. Assume relative motion in the $x\,x'$ direction and the Lorentz transformation from the first to the second system is:

$$x'=\frac{(x-vt)}{\sqrt{1-(v^2/c^2)}}$$ (where v is relative velocity and c is the velocity of light)

$$y'=y$$

$$z'=z$$

$$t'=\frac{t-\frac{vx}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}}$$

Thus the velocity of light is seen to be the limiting velocity for objects in relative motion.

Further, the apparent increase in mass of an object in motion relative to an observer may be investigated by examining the function:

$$m = \frac{m_0}{\sqrt{1-(v^2/c^2)}} \text{ (where } m_0 \text{ is rest mass).}$$

Actual numerical values for mass may be computed for particles such as electrons or neutrons when they are accelerated to velocities near c, which is approximately 3×10^{10}cm/sec. Students may plot graphs of m versus v for the high velocity region to emphasize the dramatic changes that take place.

Most high school students cannot understand the derivation of such relations but they can postulate them as closely describing the way matter behaves based on actual experimental evidence. Thus an appreciation is developed of the fact that science in its attempt to show "how" events happen can completely describe this by using mathematical functions that satisfactorily predict these events. The formulas of Newtonian Mechanics lived unchallenged for many years until refined measurements showed unsatisfactory predictions and inconsistency. So Relativity was born as a new philosophical and mathematical structure that describes nature more closely. And, to project the thinking, when and if a system is promulgated which more adequately describes and predicts the workings of the universe, it in turn will supplant or supplement Relvtivity. One does not despise the deposed system, however, since Newtonian Mechanics adequately describes the behavior of matter for most of the familiar things of life. An automotive engineer does not need Relativity or Quantum Mechanics to solve his problems, but the designer of the power section of tomorrow's space vehicle may.

Other mathematical concepts which bear on Relativity and which may be taught in high school include the invariance of certain factors under specified transformations. Thus Euclidean Geometry is a geometry in which physical properties of size and shape remain invariant under the transformations of translation, rotation, and reflection. Another idea that can be investigated is the comparison of discrete and continuous functions. Our universe in Relativity is conceived as a four-dimensional space-time continuum; but radiated energy is conceived in Quantum Mechanics as being discrete. On this same topic a study of the statistics of probability can be begun on the high school level. Probability has taken on tremendous proportions in much modern work in science and is often not adequately covered or even introduced in the advanced algebra courses of high school.

Accuracy of measurement, significance of numbers, and scientific notation, especially for very large or very small numbers, can contribute to mathematics students' background as an aid to the compu-

tations involved in the applications or testing of Relativity formulas. The method of extrapolation is another procedure that can be introduced on the high school level as a predictive technique.

Relativity, as does any other phase of science, has as its best mathematical preparation on the high school level an understanding and mastery of the fundamental concepts of mathematics. The problem that is faced by the high school mathematics educator is to determine what are the most fundamental concepts that should be included, how can teachers be adequately trained in these concepts, and what methods may be employed to bring them to full understanding in the students.

NEW METAL-GLASS FIBER MAKES PLASTIC STRONGER

Fibers from a new type of glass that partially turns into a metal during production make reinforced plastic structural materials stronger, longer-lasting.

The fibers are drawn from glass containing up to 20% copper oxide which is converted to metallic copper when the glass is heated and drawn in an atmosphere of nitrogen gas. Plastics form a tighter bond with copper surfaces than they do with ordinary glass surfaces.

The copper-coated glass fibers still are difficult to make and they contain too many imperfections for immediate use, but the researchers believe further work will result in fibers that not only can be used in laminated plastics, but could be used for reinforcing metals as well.

ANTICOAGULANT DRUG HELPS ASTHMA ALSO

An anticoagulant drug used in heart patients has been found to help bronchial asthma as well as blood circulation.

The anticoagulant is warfarin (Coumadin) sodium and after its anti-asthma effects were noted in several heart patients it was tested on the windpipes of guinea pigs. The researchers found that the drug had a definite dilating ability and was about half as effective as aminophylline, a widely used asthmatic drug.

It has been pointed out that some of the beneficial action of anticoagulants in myocardial infarction (heart attacks) may be due to properties other than that affecting coagulation

The initial dose of the anticoagulant in humans could possibly produce an immediate dilation of the bronchial tubes as well as starting the slower anticoagulant action.

SUN HAS MAGNETIC HALO FOR STORING COSMIC RAYS

The sun has a magnetic halo for storing cosmic rays produced by solar flares, giant tongues of gas exploding from the sun's surface with the violence of millions of hydrogen bombs.

Cosmic rays are mysterious atomic particles ceaselessly bombarding earth from outer space. Some come from the sun, but the origin of most is not known. One of the largest solar flares ever recorded, Feb. 23, 1956, resulted in a tremendous increase in cosmic ray intensity, more than 2,000 times the normal level.

From studies of the exact times at which this increase occurred around the world, it has been found that high energy cosmic rays arrived on earth about nine mintues ahead of the low energy ones. A magnetic envelope around the sun could account for this storage effect.

METHODS OF SELECTING FRESHMEN FOR ACCELERATED WORK IN MATHEMATICS*

W. J. CHERRY

J. Sterling Morton High School and Junior College, Cicero, Illinois

J. Sterling Morton High School in Cicero, Illinois, stands near the center of a district populated by well over a hundred thousand people. Five thousand boys and girls pour out of the building at intervals during the afternoon and stream to various parts of an area encompassing vast manufacturing plants, vibrant thoroughfares of commerce, and modest residential sections dotted with tile-roofed bungalows that betoken an average family income of $7000. Within this school population, drawn from the homes of industrial workers, merchants, and professional people, there are youngsters who can scarcely read above the fifth grade level; there are others whose abilities are sufficient to carry them through high school with ease and competence; and there are some whose mental maturity places them well up among the collegians.

For this latter group Morton has made numerous provisions through creative writing classes, courses in college mathematics, superb offerings in music, and special projects in art, science, and language. Through a rich and varied curriculum, comparable to those of most large high schools, many gifted students have found themselves. But perhaps this is not enough. Recent studies tend to show that talent will not always reveal itself but must be sought and nurtured. Investigations further indicate that our brightest youths can accomplish even more than we have required of them in the past.

It was in consideration of such findings as these that Morton decided to inaugurate a four year program for the gifted in mathematics. Such an undertaking, according to authorities, should have three goals: discovery, development and utilization of talent. This paper is concerned with discovery.

In the spring of 1956 the Department of Mathematics of Morton conducted a testing program in forty grammar schools, both public and parochial, and selected ninety students from an incoming freshman class of sixteen hundred. These ninety students were to be divided into three classes.

Five criteria were used in the screening: an arithmetic test and a mathematics aptitude test provided in the Iowa Algebra Aptitude Test; a reading test combining the Stanford Achievement and Advanced Reading tests; the recommendations of teachers; and the Otis Classification Test, which combines the educational quotient with the

* Paper presented at the Convention of the Central Association of Science and Mathematics Teachers, Chicago, Illinois, November 30, 1957.

intelligence quotient. The bottom scores for the selected group in the arithmetic and mathematics aptitude tests were equivalent to a percentile rank of 70 and 87, respectively. However the great majority were well above the 90 percentile mark on both tests. The range of C.I.'s (classification index) was 135–117. A student thirteen years of age having a perfect score on the Otis test can attain an I.Q. rating of 137, so that the test can hardly be said to differentiate satisfactorily at the higher levels, but it is excellent for general classification purposes and has been used at Morton for years. The range in reading comprehension was 14.7 to 9.6. However there were only two students below the high school sophomore level and only thirteen below the junior level. The median score was 11.7, which is just about high school senior level; and it must be borne in mind that these students were still in grammar school, just finishing their last year. The high score of 14.7 represents reading ability of about the college junior level, and the boy who made that score was found by the Kuhlmann-Anderson test to have an I.Q. of 179.

Two meetings with parents were held in the summer of 1956 and various aspects of the projected program were carefully scrutinized. Such matters as grades, homework, emotional tension, social adjustment, and specialization were discussed in a free give-and-take fashion with the result that the parents were not only convinced of the merit of the plan but were highly enthusiastic about it and delighted that their youngsters had been admitted to the group.

Conceivably such a singling out of able students might cause murmurings of resentment among the parents of less-favored children—and this might be quite likely in a small school—but at Morton the selection of ninety students out of an incoming class of sixteen hundred created no unhappiness that could be detected. Nevertheless the school was fully aware that the line of selection had been arbitrarily drawn at a certain level and that there would probably be students who, by dint of hard work and excellent study habits or by reason of the sudden blooming of latent talent, would eventually outdistance some of those among the chosen few. It seemed possible also that some of the youngsters in the screened groups might not measure up to what was expected of them and would drop out of the course. Constant watchfulness, therefore, was imperative.

The first year's work covered elementary algebra and parts of intermediate algebra—about a half-year of acceleration. As the three classes progressed, the Mathematics Department tried to do three things; namely, evaluate the achievements of the group by such standards as were available; determine the reactions of student and parents as the full force of the program began to be felt; and, with the

aid of the Counseling Department, continue the testing program begun in the grammar grades.

Had the methods used in selecting the three honors classes really screened a group of exceptionally able students? There was no comparable group in the freshman class with which to compare them, but there were many results which helped the three teachers of the special classes to decide whether they were working with really gifted students and whether there were any who did not belong. The semester final examination, which is a standardized test with established norms revealed that the honors groups were well out in front, but it also disclosed that there were some very competent students in the rest of the freshman class. In the honors group there were twenty-six students in the 99 or better percentile rank; in the rest of the freshman class there were four. In the honors group there were nine students in the 99+ percentile rank; in the rest of the freshman class there was one. There were two perfect papers in the honors group. There were sixty-two students in the honors group with percentile rating of 95 or better; there were fifty-two students in this category in the rest of the freshman class. There were eleven students in the honors group with percentile ranking below 90 but none below 80. This particular test measures skill in the mechanics of algebra but is hardly a satisfactory test for ability in handling abstractions. Had a test of the latter type been used, the divergence would almost certainly have been greater.

A test devised by the teachers of the honors groups and given at the end of the second term is considerably more difficult than the semester final. Two junior classes in intermediate algebra were given the same test. The junior classes were heterogeneous, composed largely of pupils of average ability but with a few brilliant students. Of course they had behind them two years' work in algebra and geometry. The freshmen had completed thirteen weeks in beginning algebra and the test covered only topics they had studied. The honors group scored higher than one of the junior classes, and, curiously, tied with the other on both the median and the mean. This speaks extremely well for the freshmen.

Another indication that the pupils in the honors group were really very excellent students was the fact that their grades in other subjects ran nearly parallel to their grades in mathematics, the mathematics grades being a little higher on the whole. However the achievements of the three classes were not uniformly high. Although there were some students whose enthusiasm and ambition were enormous, there were others who began to lag as the work progressed; and thus it will probably always be, for there are factors in the lives and en-

vironment of youngsters thrown suddenly into the maelstrom of a large high school that elude even the most astute counselor; and there is also a certain force of personality commonly known as drive in which some individuals appear to be sadly wanting. Regarding this latter quality the Educational Policies Commission states: "Other factors contributing to achievement include maturity, motivation, diligence, and efficiency of study habits. Such factors are sometimes called 'drive,' with respect to which individuals appear to differ from one another as markedly as they differ with respect to intelligence."

It was to minimize the number of students lacking in staying power that the Head of the Mathematics Department prepared a questionnaire which was sent last spring to the grammar grade teachers of prospective candidates for this year's honor classes. The paper outlined the physical, mental, social and emotional traits of gifted pupils and asked for a check of each characteristic that was observable in a particular pupil. The results were helpful, especially in borderline cases; but a questionnaire is not a flawless instrument and many of the replies were not consistent. No doubt there is no perfect method of screening pupils for honors classes. Nevertheless the methods used provided a hard core of genuine talent.

One of the fine things about a program for exceptional students is that enthusiasm takes fire and spreads. The project at Morton has elicited so much interest on the part of the faculty generally and has proved so fascinating to the teachers directly involved that others have offered to contribute time and energy in various ways. One member of the mathematics faculty, for example, made a study of pupil and parent reactions to the program, using the questionnaire technique to obtain his data. A summary of his findings is as follows:

"Overall, the responses to the questionnaires seem to indicate a satisfactory condition with respect to the effects of the accelerated mathematics course on the student. They reveal a high level of interest in the course and a high percentage of aspirants to college and the professions. They seem to reenforce the argument that all gifted students need to have some of their experiences with the non-gifted. There is no evidence of class-consciousness or of non-acceptance of one group by another, and any hint of conceit is inconclusive. As to maladjustments, a very small percentage of responses indicated such conditions as tensions, nervousness, and discouragement as a result of competition and overwork. Generally, however, both students and parents seem to be satisfied with the course."

The Head of the Counseling Department at Morton has followed the progress of the accelerated classes with unabated zeal. Feeling that the C.I. scores did not differentiate satisfactorily at the top levels, he administered the Kuhlmann-Anderson Test H toward the

end of the past school year with interesting results. Regardless of the measure of faith a teacher has in intelligence tests, he has only to examine the responses of a dozen or more top-flight students to see that some of the youngsters are remarkably brilliant. It is not to be inferred, however, that those who scored lowest should be eliminated on that account alone, for there are five other criteria on which to base judgments.

The I.Q.'s for the classes tested ranged from 179 to 107. 11% of those tested scored above 150, 30% scored 140 or above, 54% scored 130 or above, 76% scored above 120, and 24% scored below 120. This indicates quite a range and points up the observation that several tests are needed. Authorities seem to agree that we can hardly overstate the case of those that make extremely high scores; that is, they really are extremely bright. However those that make low scores may be more able than the record indicates. Fortunately we have other data on them.

Another test administered by the Counseling Department is a primary mental abilities test published by the Science Research Associates. The battery includes exercises in verbal meaning, space, reasoning, number, and word fluency. It is designed to show in which skills a student excels and in which he is less adept. An I.Q. equivalent for the whole performance is indicated more or less roughly. Conferences were held with individual students and the results were interpreted with such reservations as seemed appropriate. The school plans to continue the testing program as the screened groups progress.

Among the good things that appear to have come out of the new program is a general quickening of interest in mathematics. Challenged by the example of the honors groups, several of last year's sophomores, by virtue of exceptional work, won permission to take the course in college algebra and trigonometry in their junior year, though the course is designed for seniors. Next year they will probably take analytic geometry in the junior college. This year the mathematics club tripled in size. Grammar school teachers are becoming more conscientious in their search for talent. Who knows? With like enthusiasm throughout the nation, we may have a veritable renaissance.

NEW ARCTIC SHIPPING LANES WILL BE OPENED

New shipping routes in the Arctic Ocean will be opened up in the next few years, an English scientist forecast at the first international conference aimed at improving methods of studying sea-ice formation.

Dr. C. W. M. Swithinbank, research fellow at the Scott Polar Research Institute, Cambridge, England, reported results of his search through the logs of all ships traversing the Canadian Arctic region since 1900. From this information and studies of aerial photographs, he compiled an ice atlas of the North American Arctic.

EFFORTS TO MEET THE CRITICAL SHORTAGE OF SCIENTISTS*

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The people of the United States have recently received a severe shock. The mythical idea that top scientific ability was limited to the inhabitants of this nation and its allies was thoroughly exploded by the successful launching of the two Russian earth satellites. We realize the immediate danger to our freedom and our mode of life which this accomplishment implies. The reaction is quite normal, a pressure to start a crash program to accelerate our exloration of outer space and with it develop long range missiles. It is imperative to our safety that we close the gap in our scientific competition with Russia.

It is far less evident that our citizens can recognize the extent of this program. We recall the sudden need of tanks and planes at the beginning of the last World War. We remember how our production increased and, by virtue of our vast natural resources, in a relatively short time we gained dominance. The present situation is completely different. Now we do not possess the natural superiority. A successful crash program is only a temporary solution to the problem. Scientific competition will not stop when we have achieved this stage. It will extend beyond this generation of scientists who are now working in their laboratories. The real question is:—Will the scientist of the next generation, the American school boy of 1957 living under the Stars and Stripes, be in a position to compete successfully with the school boy trained under the Hammer and Sickle?

The production of trained scientists is in no way comparable to the building of planes and tanks. The development of intellectual skills, "eggheads," if you please, is a process involving years of time. Unfortunately our production is in the "too little and very late" stage. Our present shortage of some 25,000 scientists is recognized as a critical situation. Yet by 1960, according to the estimate of the Scientific Manpower Commission, there will be a shortage of twice this number. To make matters worse, a decreasing percentage of our talented youth is now electing science as a vocation. In fact only half of high school graduates of the top quarter in ability are in college; many cannot afford the high cost of higher education.

The nation cannot afford this waste of its intellectual resources at a time when trained leadership is so badly needed. Somehow the education of gifted youth must be continued even though the walls of the college class rooms already bulge with students, and even though

* Paper presented at the Meeting of The Central Association of Science and Mathematics Teachers, Chicago, Illinois, November 30, 1957.

their number is expected to double in the next decade.

College administrators worry over ways of doubling the capacity. Perhaps we should recognize that it is not mere volume which is important in higher education, but high quality. Perhaps this period of stress should be accepted as an opportunity to remake higher education what it is intended to be, a full opportunity for intellectual advancement to the youth who can and who will profit from an atmosphere of advanced scholarship. It is not the place to permit the uninterested to water-down the courses.

The citizens of this country have always been willing to pay for national defense. Is it not clearly evident that we have passed from an age of dependence on planes and tanks to an age in which the survival of our nation depends on new ideas, new concepts and new intellectual skills? The history of the future will be determined by the educated leadership we develop now. Youth with aptitudes in all areas of advanced learning must be sought out. Provisions must be made for their full intellectual development so that we can hold our own on the face of this competitive globe.

The greatest need for financial help, taxpayer's money, is in the undergraduate college. The graduate students have a reasonable number of assistantships, fellowships, etc., but there is very little in comparison to help the needy undergraduate. The public is evidently unaware of the full meaning of this need. Since 1900 a steadily decreasing percentage of our national income has been allotted to education. In comparison huge sums of money are spent on non-essentials, on luxury and pleasure items. It is not a question of being able to afford more educational support, it is entirely a matter of failing to place the money where it is needed. Should we compare our present actions to Nero's fiddling while Rome burned?

Let us look at another angle of this problem which may point out some solution to remedy this bad situation. In recent weeks scores of articles have been printed lamenting the fact that European students advance educationally at a much faster pace than our own. Certainly this is a most critical element in the competition. What is the reason for the difference? Why is it necessary to play down the simple elements of trigonometry in our college physics classes when the subject is presented to a comparable European group with Calculus? Are American students less intelligent or is the public satisfied with a lower grade of achievement of its youth? No one would admit that American students are less intelligent. Perhaps they reflect adult effort and emphasis. Life is easy in this land of plenty and there is a tendency to be more concerned about economic success than intellectual success.

The teacher can help to set a scholastic atmosphere but he cannot

do it alone. The product of the class room is not too different from the product in any market. What you want badly enough to pay for, you are very likely to get. Let us look at some class room facts. Last year in New York City alone 10,000 students enrolled in science classes were taught by teachers not trained in science. Is this the type of instruction which the public wants to buy? At present they can do no better, since there is only one qualified science teacher available for every five unfilled science teaching positions.

How can the situation be changed? Last spring it was announced that the Ford Foundation was investing $25,000,000 in a five year program to allot 1000 very substsntial fellowships as a recruiting program to encourage able students to select college teaching careers. This is an excellent idea,—but you and I know the real difficulty is not corrected in that way. Consider the fact that thousands of teachers, already prepared, have been forced to change their profession to make ends meet. The present buying power of teachers' salaries, I need not tell you this but I want it in the record, is approximately 70% of the buying power of the teachers' 1940 salaries. We need no crystal ball to tell us that the real solution lies in producing adequate inducements throughout the lifetime of the teacher so that it is not necessary for him to continue to ask, "Can I afford to do this work I want to do?"

Sputnik exploded the myth of our easy scientific superiority. What type of Sputnik will be necessary to explode the equally fallacious idea that our educational advancement is in no way dependent on public esteem or recognition of the teacher by an adequate sharing with him of our great economic bounty?

Consider the answer received by the teacher who asked, "What is the mechanical advantage of a long pump handle?" and the student replied, "The mechanical advantage of a long pump handle is so that lots of people can get hold of it." To prime the pump, the subject of this paper, requires that we all pull together as individuals and in groups. The problems faced by physics teachers in college are very similar to those faced in the secondary schools.

One of the most active organized groups at work on these problems is the American Association of Physics Teachers, commonly referred to as A.A.P.T. Several here are members. I have selected to speak of only three of their fields of activity.

First we shall consider the program of Visiting Scientists. There is a great need to seek out scientific talent at all places and at all age levels. Many renowned scientists have received their undergraduate training in small, rather isolated, colleges. It is a good atmosphere and there is a likelihood that more graduate science students could be recruited from these areas by the stimulation of visits by prominent scientists.

To further this work the American Association of Physics Teachers (A.A.P.T.) has instituted a program of Visiting Scientists. Some sixty-five selected, prominent physicists, Nobel prize winners included, have agreed to make visits of three or four days' duration to the small colleges. Approximately one hundred colleges have requested visits. During these visits there are formal and informal meetings with the students and the staff to discuss physics in terms of subject matter and as a vocation. Since it is so important to keep the public informed, each visit includes a public lecture. The cost is divided. Part is paid by the college visited and the balance by a grant from the National Science Foundation.

The response to this program has been so enthusiastic that we hope next year not only to continue the college visits but also to institute a comparable program of visits to high schools. The experiences of young people in the secondary and the grade schools is vitally influential in their later selection of a vocation. We hope to emphasize physics as one of the selections. I believe this program, which will be operated provided requested funds are made available, can be of great help to you.

Another program of A.A.P.T. is carried by its Committee on Apparatus. We all know how important good demonstration and laboratory equipment is in the teaching of physics. We also know the frustration nearly everyone here has experienced when, through inadequate funds or unavailable apparatus, we have been forced to do a mediocre job of teaching. The problem of the committee is essentially one of trying to provide the best possible apparatus at a price such that it can be made available in any class room or laboratory.

We are constantly shocked at the prices of equipment, failing to recognize that the price reflects the high building costs of manufacturing in small quantities and at much risk. The first job of this committee, incidentally it was financed by a local apparatus firm, was to survey the basic needs of physics departments. The committee now has data on the pieces which are wanted in quantity and could be purchased at the more reasonable costs made possible by larger scale manufacturing.

In this survey new locally-built apparatus was unearthed. At the next annual meeting of the Association, thirty of these pieces, selected as outstanding, will be on display. It is probable that some of these will be added to the too static lists we have memorized in apparatus catalogues.

At the present time this Committee is working on the distribution of government and industrial surplus. There is excellent surplus apparatus available in quantity at very low costs; the trouble has been lack of knowledge of the sources. It would be wonderful if, in addition

money, big money, could be located to help defray the costs of the type of teaching equipment needed so badly in the teaching of physics.

I shall mention only one more activity of the American Association of Physics Teachers. With the present drastic shortage of science teachers and the fact that the new supply fails to meet the annual loss, it is certain that mass media, such as motion pictures, must be used to teach the large increase occurring in student population. Thus new and very powerful tools are being fashioned. They must not be introduced into the classrooms without careful evaluation and constant testing. Several of you have already cooperated with our Association on such evaluation. We ask for more to join forces with us.

The Physical Science Study Committee is an outstanding example of group action to satisfy a need in our profession. We will all be affected by what this committee, operating initially under a large N.S.F. grant, is doing. Its revision of secondary school physics is most thorough. I have here the first volume of the new text the committee and its staff is preparing. This is an up-to-date, interesting presentation. You may wish to see it later. Besides the text they will prepare a new laboratory plan including new experiments, new apparatus and a variety of teaching aids.

It is very likely that our college work will undergo the same scrutiny and revision. That job has been under consideration, but never at this level. I think it would be wise for all here to hold an open mind towards these revisions and make judgment only after the final product has been carefully examined and tested.

Now we return to the most important element in the solution of our national problem, the critical shortage of scientists. That element is you, the teacher in science. What you do as an individual in the classroom and beyond its walls carries more weight than you may recognize. I hope you never feel a real desire to follow the all too general American custom of taking advantage of the critical need of your services as an undue pry on the public for selfish gain. At the present time, however, it is not high motivation that should keep you on the job. It is the hardheaded recognition that if you value freedom for yourself and those you cherish, you will help develop future scientists. There is much evidence that the public is beginning to see what is happening. It will accept its responsibility when it discovers that the product it needs and wants exists through the efforts of this neglected group.

Along with the teaching of the principles of physics you must now, more than ever, be conscious of the part you play in the competition of the next several decades. You have students with science interests and talents. They will weigh you and your actions against the back-

ground picture which they have formed, through their various avenues of learning, to help them decide whether or not they want science as a vocation.

In this job you have two strikes against you. The picture of science and the scientist in the mind of the high school student is not, at present, conducive to selection of science as a vocation. Read the article "Image of the Scientist Among High School Students," published in *Science* August 30, 1957. It is a composite picture gathered from the confidential statements of 35,000 high school students in a survey sponsored by the American Association for the Advancement of Science. Wait for a bright, sunny day before you read it.

Briefly the composite picture of the scientist as the high school student sees him is that he is, in the proper vernacular, "an egghead and a queer." He has no interests other than science. He works alone, incessantly, in frustration, hoping always that some day, perhaps years removed, he will get the answer to his problem so that he may stand up and shout: "I've found it! I've found it!"

And now that we have this picture of what a scientist is like and I look about this room, the horrible thought strikes me that I see no scientists in the audience. You appear to be normal, intelligent and reasonably happy human beings. In fact, I don't even recognize that any one of my colleagues can thusly qualify as a scientist.

It is obviously clear that our big professional job is to present a truer picture of the scientist and of science and its contribution to society. To do this we must know all contributing phases of this rapidly growing subject. Our knowledge of the physics of yesterday is insufficient for today's classes. Today we need to give practical consideration to the physics of outer space transportation, a subject of minor theoretical interest such a short time ago. There is a vital reason to attend the Institutes for Science Teachers now held in various areas of the country.

We dare not succumb to the idea, to quote a recent speaker, that "our situation is so grave a crisis that we are beginning to accept its dangers as a necessary future situation." That would be fatal. We have faced other crises successfully and I am confident we will help to weather this one by proving to the talented youth in our classes that the vocation of science, physics in particular, is a dynamic adventure in which he should be happy to share.

AUTOMATIC DEVICE AIDS BAD WEATHER FLYING

An automatic device that helps keep small personal planes on course, even when hit by unexpected soupy weather, has been developed by scientists at the NACA's Langley Aeronautical Laboratory.

THE ELEMENTARY SCHOOL SCIENCE LIBRARY FOR 1956–1957

PAUL E. KAMBLY
School of Education, University of Oregon, Eugene, Oregon
AND
ELEANOR E. AHLERS
Executive Secretary, American Association of School Librarians

This is the fourteenth yearly list of books for elementary school science compiled and published in SCHOOL SCIENCE AND MATHEMATICS. The purpose, like that of preceding lists, is to suggest to elementary school teachers books that are supplementary to basic text series either for their values as sources of information of for recreational reading. Certain books included primarily because of assumed value as recreational reading are below desired standards of good sources of science information. The sub-division topics are of no significance except as an aid in grouping the references.

Exact grade placement is difficult because of variations in pupil reading ability as well as in different uses made of the books. The lowest grade levels for pupil use are indicated.

BOOKS FOR ELEMENTARY SCHOOL SCIENCE[1]

Ancient Animals

	Grade	*Price*
You and How the World Began. By Mary Lou Clark. 62 pp. '57. Children's Press. Briefly explains two theories regarding the formation of the earth. Traces the development of life on the earth from the single celled plants to early man. A great many theories concerning racial development are of necessity omitted.	5	$2.00
The First Book of Archaeology. By Nora Benjamin Kubie. 64 pp. '57. Watts. What is a day on an archeological site really like? How does an archeologist know where to dig? What does he look for in digging? How does he trace the history of the things he excavates? All are answered briefly.	6	1.95

Animals

(See also list of books on birds and insects)

The Farmer and His Cows. By Louise Lee Floethe. 32 pp. '57. Scribner. Young children will enjoy this excellent comparison of dairy farming "then and now." Large colorful illustrations make up the major portion of this book.	1	2.75
Step-A-Bit—The Story of a Foal. By Sam Savitt. 68 pp. '56. Dutton. Pencil drawings record the events in the life of a filly from birth to the time she is taken from her mother.	1	2.95

[1] Publishers and their addresses are listed at the end of this section.

	Grade	Price
The True Book of Reptiles. By Lois Ballard. 48 pp. '57. Children's Press. Four types of reptiles are described—Reptiles with Shells on Their Backs, Reptiles with Four Legs that Live on Land, Reptiles with Four Legs that Live in Water, and Reptiles with no Legs. Many clear pictures illustrate the easy-to-read text.	1	$2.00
Horned Lizards. By M. Vere DeVault and Theodore Munch. 30 pp. '57. Steck. The physical characteristics, habitat, habits and behavior of the horned lizard are simply described in large print, with pictures on every page.	2	1.50
Who Lives in This House? A Story of Animal Families. By Glenn O. Blough. 48 pp. '57. Whittlesey. An easy-to-read story about the animals that live in and around an old red house. Included are robins, wasps, squirrels, bees, spiders and skunks. Illustrated by Jeanne Bendick.	2	2.50
Animals of the World, Volume I. By Edward Osmond. 128 pp. '56. Oxford. Four booklets covering the habits and habitats of elephants, camels, polar bears, and chimpanzees have been bound into one volume. Well illustrated by pen drawings.	3	2.25
Animals of the World, Volume II. By Edward Osmond. 128 pp. '57. Oxford. The distribution, natural history and importance to man of kangaroos, reindeer, beavers, and whales are described and illustrated by pen drawings.	3	2.25
Here Come the Beavers! By Alice E. Goudey, 94 pp. '57. Scribner A simple true-to-life story of a family of beavers in the Adirondack Mountains. The last section of the book tells how and why beavers are sometimes parachuted down from planes in the western United States.	3	2.50
Here Come the Seals! By Alice E. Goudey. 93 pp. '57. Scribner Another simple life story of two types of seals—the young fur seal and the young harp seal.	3	2.50
Leaper, the Story of an Atlantic Salmon. By Robert M. McClung. 64 pp. '57. Morrow. The life of Leaper, beginning with his emergence from an egg and on through the five years before he leaves the ocean to fertilize eggs in the stream where he spent the first two years of his life.	3	2.25
Mice at Home and Afield. By Olive L. Earle. 63 pp. '57. Morrow. The habits, habitat, and physical characteristics of white-footed, jumping, pocket, grasshopper, field, pine, red-backed, and tree mice are described in simple style with ample illustrations.	3	2.25
Moles and Shrews. By Charles L. Ripper. 64 pp. '57. Morrow. Excellent illustrations assist the simple narrative style of the text in explaining the habits and natural history of these two insectivores. The different species common to the United States are identified, and misconceptions corrected.	3	2.50
All About Strange Beasts of the Present. By Robert S. Lemmon. 148 pp. '57. Random. Strange animals of the United States and Canada, at the North and South Poles, in the tropics and sub-tropics, and	4	1.95

	Grade	Price
in the South Pacific. Drawings supplement the interesting text.		
Cottontail Rabbit. By Elizabeth and Charles Schwartz. 46 pp. '57. Holiday. An excellent story of one year in a female cottontail's life. Of the four families she raises during the summer, fifty per cent survive. The importance of rabbits in the "food chain" of the wildlife community is emphasized in this accurate, but simple narrative.	4	$2.50
Pagoo. By Holling C. Holling. 86 pp. '57. Houghton. An exciting and somewhat humanized story of a hermit crab, in a handsomely illustrated book, with scientifically drawn pictures in the margins.	4	3.75
Big Jack. By Roswell Greene and Robert Candy. 52 pp. '57. Houghton. A fascinating story of the trout Big Jack from his beginning in the fish hatchery through all stages of his life. Excellent pencil sketches enhance the beauty and accuracy of this small book.	5	3.25
The First Book of Mammals. By Margaret Williamson. 64 pp. '57. Watts. General characteristics of mammals, their methods of locomotion, food getting, homes, reproduction and growth are all included in this "first book." Illustrations by the author add interest to the text.	5	1.95
Zoo Doctor. By William Bridges. 126 pp. '57. Morrow. Some of the doctoring experiences of the veterinarian of New York's Bronx Zoo. Good illustrations of the patients.	5	2.95
Reptiles Round the World. By Clifford H. Pope. 194 pp. '57. Knopf. A source book on snakes, lizards, turtles and crocodilians for good readers. Includes a chapter on reptiles as pets. Excellent drawings and maps.	6	3.00
Astronomy		
Exploring Mars. By Roy Gallant. 62 pp. '56. Garden City. An illustrated history of the study of the planet Mars from the sixteenth century to the present time. Distinguishes between speculation and fact.	4	2.50
Comets. By Herbert S. Zim. 64 pp. '57. Morrow. Many of the known facts about comets are presented. Effective diagrams and drawings help to clarify the text.	5	2.25
This Way to the Stars. By John M. Schealer. 181 pp. '57. Dutton. An attractive approach to astronomy from earliest times to a trip into outer space. Good diagrams and photographs.	6	2.95
Birds		
City Birds. By Lucy and John Hawkinson. 32 pp. '57. Whitman Describes the Purple Martin, English Sparrow, Night-Hawk, Robin, Chimney Swift, Starling and Pigeon. The major portion of the book is devoted to illustrations.	3	2.00
The Adventure Book of Birds. By William A. Jerr. 90 pp. '57. Capitol. Not intended primarily as a book on bird identification. Includes material on ancient birds, how birds fly and their	5	2.95

	Grade	Price
influence on human beings. Also some information about bird houses and ways of attracting birds.		
Run, Sandpiper, Run. By Lloyd L. Goff. 30 pp. '57. Lothrop. A story of the migration of sandpipers from South America to Labrador and the raising of a family.	5	$2.50
Dipper of Copper Creek. By John and Jean George. 184 pp. '56. Dutton. Doug spends a summer in the Colorado Rockies with his grandfather. He thought his main interest would be in mining gold but it actually turns out to be watching the water ouzel or dipper bird. An outstanding animal story, well written.	6	3.50
Conservation		
Soil Savers. By C. B. Colby, 48 pp. '57. Coward-McCann. Brief description of the Soil Conservation Service of the United States Department of Agriculture and its work with farmers and forestry men in planning techniques that will save the land. Excellent photographs make up the major portion of the book.	5	2.00
Sun, Earth, and Man. By George P. and Eunice Bischof. 118 pp. '57. Harcourt. After a brief description of the universe, the authors discuss man's relationship to his world and to his environment, his responsibilities in using natural resources, and the necessity for understanding among peoples.	6	2.75
General Nature Study		
The Hole in the Tree. By Jean George. 47 pp. '57. Dutton. This delightful picture story book tells how a hole in a tree was started and gradually enlarged to accommodate each new inhabitant—a bark beetle, a bee, a chickadee, a deer mouse, a downy woodpecker and finally a raccoon family. A story of wonder and scientific accuracy to read to primary grades.	1	2.50
Tropical Rain Forests. By Delia Goetz. 64 pp. '57. Morrow. A beautifully illustrated description of the weather, plants and animals of tropical rain forests, as well as information about the primitive people who dwell in these forests.	3	2.50
All About the Desert. By Sam and Beryl Epstein. 148 pp. '57. Random. Describes deserts of Africa, Asia, Australia, South America and North America. Plants and animals that inhabit these deserts are pictured by Fritz Kredel.	4	1.95
Secrets of Life. By Rutherford Platt and the Staff of the Walt Disney Studio. 124 pp. '57. Simon & Schuster. Another of the "A True-life Adventure" series based on the film. This book discusses such topics as soil, pollination, volcanoes, and the habits of bees and ants. Beautiful photographs in color.	4	2.95
Picture Book of the Sea. By Jerome S. Meyer. 29 pp. '57. Lothrop. Simple and attractive picture-science book with facts about the origin of the ocean and plant and animal life in the sea.	4	2.50
Experiments with a Microscope. By Nelson F. Beeler and Franklyn M. Branley, 154 pp. '57. Crowell. An excellent book for the person interested in studying microscopic organisms. Begins with information about a	5	2.75

	Grade	Price
microscope and leads the beginner step by step through the study of organisms such as protozoa, molds, yeast, and bacteria.		
Exploring under the Sea. By Sam Hinton. 64 pp. '57. Garden City. Waves and tides, plants and animals in the tide pool, the shallow sea, the open sea and its depths—all are explored and discussed in this interesting book.	5	$2.50
Illustrated Book of the Sea. By Leon A. Hausman and Felix Sutton. 101 pp. '57. Grosset. A handsome book illustrated in color and accurately presenting information about all the plants and animals, large and small, that inhabit the sea.	5	3.95
Let's Explore Beneath the Sea. By William Knowlton. 139 pp. '57. Knopf. A popular account of the experiences of a skin-diver. In addition to the advice given for that sport the author has included information about spearfishing and shell collecting.	5	3.00
Rainbow Book of Nature. By Donald C. Peattie. 319 pp. '57. World. In this attractively illustrated book a naturalist writes about animal and plant life of the various regions and during different seasons of the year. A list of classified nature books, magazines, films and recordings is included.	5	4.95
See Through the Jungle. By Millicent Selsam. 55 pp. '57. Harper. A trip through the various layers of vegetation which make up a jungle. The tapir, anteater, gecko lizard, orchid, and howler monkey are some of the living things described in words and pictures. Reinforced binding.	5	3.25
Swamp Life. By Glen Rounds. 117 pp. '57. Prentice-Hall. "An almanac dealing with raccoons, possums, snakes, turtles, hell divers, wood ducks, and others who live in the hollow trees, tangled thickets, and swampy places along Little Fiery Gizzard Creek, with a few words of advice on how to see and become acquainted with them." Useful to encourage nature study.	5	3.00
Wonderful World of the Sea. By James Fisher. 68 pp. '57. Garden City. Pictures, diagrams, maps, many in color, make this description of the sea and the life within it particularly attractive for browsing.	5	2.95
Sea Treasure; a Guide to Shell Collecting. By Kathleen Y. Johnstone. 242 pp. '57. Houghton. An attractive narrative style of writing makes this book on shells extremely readable for those interested in shell collecting as a hobby. Clear diagrams and some illustrations in color. Bibliography and index.	6	4.00
General Science		
It's Snowing. By Edith Thacher Hurd. 32 pp. '57. Sterling. Facts about weather forecasting and the conditions necessary for snow to fall are cleverly interwoven in this story about how different people react to and are affected by snow. Large drawings that children will like make up most of the book.	1	2.50
Rusty Rings a Bell. By Franklyn M. Branley and Eleanor K.		

	Grade	*Price*
Vaughn. 32 pp. '57. Crowell. Rusty's father shows him how to connect a dry cell battery with a doorbell to make it ring. An excellent and safe introduction to current electricity for children even before they enter first grade.	1	$2.50
What Could You See? By Jeanne Bendick. 32 pp. '57. Whittlesey. Pictures with simple text to describe what might be seen in looking at shells, stars, rocks, the woodland, the weather, the zoo. Reinforced cloth binding.	1	2.00
The Golden Picture Book of Science. By Rose Wyler. 57 pp. '57. Simon & Schuster. A picture book of science for younger children. Includes facts about animals, plants, weather, etc., and experiments and activities.	2	2.50
Let's Go to a Dairy. By J. M. Goodspeed. 48 pp. '57. Putnam. A description of what happens to raw milk in every step of its journey from the dairy farm to you. This is an excellent book to use when planning a field trip to a dairy farm or dairy and after returning to the classroom.	2	1.95
Shadows. By Larry Kettelkamp. 64 pp. '57. Morrow. How to have fun with shadows, such as casting animal shadows with your hands, makes up the first half of the book. The second half tells about some of the scientific discoveries that have been made because of shadows.	3	2.50
Your Wonderful World of Science. By Mae and Ira Freeman. 84 pp. '57. Random. Basic information about the earth, sun, rocks, soil, and elements of the weather such as clouds, rain, fog, and snow. Good drawings help clarify the concepts presented.	3	1.95
All About the Arctic and Antarctic. By Armstrong Sperry. 146 pp. '57. Random. A description of weather conditions, rock and land formations, ocean currents, and plant and animal life at the North and South Pole. Maps and drawings supplement the text.	4	1.95
All About Great Rivers of the World. By Anne Terry White. 150 pp. '57. Random. The story of the Nile, the Amazon, the Yangtze, the Volga and the Mississippi, and of man's dependence upon the great rivers and his constant efforts to control them. A combination of science and social science.	4	1.95
The Story of Rivers. By Ray Bethers. 48 pp. '57. Sterling. The history of rivers with an emphasis on present day rivers and their importance to man. Many drawings supplement the text.	4	2.50
All About Electricity. By Ira M. Freeman. 141 pp. '57. Random A clear account of electric current, electromagnets, meters and motors, telephone, wireless, radio and television. Many diagrams supplement the text of this very informative book.	5	1.95
Exploring the Weather. By Roy A. Gallant. 64 pp. '57. Garden City. An attractive and informative book about the weather, with many pictures and diagrams in color.	5	2.50
The First Book of the Antarctic. By J. B. Icenhower. 68 pp. Watts. A member of the U. S. Navy's Antarctic expedition of 1946–	5	1.95

	Grade	Price
1947 describes scientists and explorers at work. The book includes material about animals, storms, the ice pack, whaling fleets, and early explorers.		
Men at Work in the South. By Henry B. Lent. 128 pp. '57. Putnam	5	$2.75
A combination of social studies and science materials. Chapters such as Atomic Energy—for Peace, Aluminum—the Wonder Metal, How Rocks Help Farmers, and Miracle Products from Chemicals illustrate the type of science information included.		
Oil, Today's Black Magic. By Walter Buehr. 96 pp. '57. Morrow	5	2.50
A brief survey of the history, production and uses of oil and how the discovery of oil has affected our lives. Well illustrated.		
The Story of Power. By Edward Stoddard. 62 pp. '56. Garden City	5	2.00
The simple text with clear diagrams and pictures make this a useful book. Includes a discussion of power from running water to atomic energy.		
Fabulous Fireball. By D. S. Halacy. 154 pp. '57. Macmillan	6	3.00
The story of solar energy and its importance to mankind now and in the future. Excellent photographs.		
Lens Magic. By Francis Rogers. 160 pp. '57. Lippincott	6	2.75
The story of glass and how it has helped man to understand the world around him is interestingly told. Interwoven is the history of famous scientists who experimented with both the telescope and microscope.		
The Real Book of Electronics. By Edward Stoddard. 215 pp. '57. Garden City	6	1.95
A simple and interesting account of the electronics field. Electricity, electronic devices and their application are all discussed.		
Rocks and Minerals. By Herbert S. Zim. 160 pp. '57. Simon & Schuster	6	2.50
More than 400 rocks and minerals are classified and illustrated in this new book in the pocket-sized "Golden Nature Guides."		
Solar Energy. By Franklyn M. Branley. 117 pp. '57. Crowell	6	2.75
Various aspects of solar energy are discussed, including its application to modern life. Clear drawings.		
Ten Miles High, and Two Miles Deep. By Alan Honour. 206 pp. '57. Whittlesey	6	3.00
Biography of Auguste and Jean Felix Piccard and the story of their ballooning into space and bathyscaphing into the ocean depths. Photographs. Index.		
Weather; Air Masses, Clouds, Rainfall, Storms, Weather Maps, Climate. By Paul E. Lehr and Others. 160 pp. '57. Simon & Schuster	6	1.95
Another in the Series of "Golden Nature Guides." This is a compact small book with many maps and pictures and filled with all sorts of information about the weather.		
Insects		
The Butterflies Come. By Leo Politi. 32 pp. '57. Scribner	1	2.75
Stephen and Lucia are children who live on Monterey Peninsula in California, where every year, in the fall, thousands of Monarch butterflies come to spend the winter. The in-		

	Grade	Price
formation about Monarch butterflies is accurate. The lovely illustrations add interest to the story.		
Luna The Story of a Moth. By Robert M. McClung. 48 pp. '57. Morrow. Very attractive illustrations and text describe the life cycle of the beautiful pale-green Luna moth.	1	$2.50
Praying Mantis. By Harriet E. Huntington. 44 pp. '57. Doubleday. A simple account of the life cycle of this interesting insect. Excellent photographs add to the accuracy.	3	2.00
Insect Engineers; the Story of Ants. By Ruth Bartlett. 128 pp. '57. Morrow. An excellent account of the life of ants. The last chapter on keeping ants in glass nests would be of great value to any group of children interested in observing and learning more about the way ants live. Clear pictures and easy-to-read narrative style of writing.	4	2.75
Insects—Hunters and Trappers. By Ross E. Hutchins. 96 pp. '57. Rand McNally. For the young naturalist this entertaining book will give pleasure. It may help to arouse an interest in insects in other children too, because of the lively style of writing and excellent photographs.	5	2.95
Insects on Parade. By Clarence J. Hylander. 208 pp. '57. Macmillan. This book is planned for the entomology student. The anatomical structure, habits, habitat and species of many insects are described in detail.	6	3.75
Physiology		
Your Food and You. By Herbert S. Zim. 64 pp. '57. Morrow. Topics included are why we need to eat, what makes up food, how we digest it, and what it does for our bodies. Numerous diagrams supplement the text.	5	2.50
Medicine in Action, Today and Tomorrow. By Margaret O. Hyde. 160 pp. '56. Whittlesey. Describes the teamwork of doctors, technicians, researchers, and therapists in developing and using new drugs and techniques in the solution of health problems the world over.	6	2.75
Plants		
Fun-Time Window Garden. By Emogene Cooke. 32 pp. '57. Children's Press. Growing plants in water and growing plants in soil are both discussed. Each suggested activity is outlined under headings such as What You Do, What to Watch For, and Things To Do. Simple, explicit instructions.	3	2.50
The Wonder World of Strange Plants. By Marie Neurath. 36 pp. '56. Lothrop. Seventeen different "strange plants" are explained in simple text and in drawings.	3	2.00
Play With Seeds. By Millicent E. Selsam. 96 pp. '57. Morrow. From Seaweeds to Seed Plants, From Flower to Seed, How Seeds Travel, Experiments with Seeds, and Uses of Seeds are the chapter titles in this excellent book.	4	2.50
Trees and Their World. By Carroll Lane Fenton and Dorothy		

	Grade	Price
Constance Pallas. 96 pp. '57. Day. Not intended primarily as a guide to identification, this book tells about the movement of liquids in trees, how trees manufacture and use food, and how they reproduce. More than 200 separate drawings by Dr. Fenton.	6	$3.25

Rockets, Jets and Space Travel

The Earth Satellite. By John Lewellen. 59 pp. '57. Knopf. Factual information about man-made satellites written before the first U. S. attempt to launch a satellite. The author says "You may be sure the news, good or bad, will fill the newspapers and radio and television newscasts." A well illustrated book that will interest many children and grownups.	4	2.25
Exploring Earth and Space. By Margaret O. Hyde. 160 pp. '57. Whittlesey. Description of some of the operations of IGY (International Geophysical Year). Topics include: earthquakes, the Antarctic oceans, weather, atomic power, the sun, rockets, satellites, and space travel. Diagrams and line drawings assist in the explanations. Index.	5	3.00
Firing Line. By C. B. Colby, 48 pp. '57. Coward-McCann. A description of weapons, vehicles, rockets, and research at the Army Proving Ground, Aberdeen, Maryland. Many children will be interested in the excellent photographs in this book and some will read the text.	5	2.00
Rockets and Missiles. By Erik Bergaust. 48 pp. '57. Putnam. A picture-caption story of American rockets and missiles. Divided into five sections—Research, Army, Navy, Air Force, and Missiles of Tomorrow. The text is not easy reading but many interested boys will read it.	5	2.00
Rockets, Missiles, and Moons. By Charles Coombs. 256 pp. '57. Morrow. Illustrated with seventy-nine photographs, the book begins with a description of an actual missile launching at Cape Canaveral and then describes various rockets and missiles being used and tested at the time the book was written.	5	3.75
Exploring by Salellite. By Franklyn M. Branley. 40 pp. '57. Crowell. This is the story of Project Vanguard told in simple text and with clear illustrations. The author explains the construction and launching of a man-made satellite.	6	3.00
Rockets Through Space. By Lester Del Rey. 118 pp. '57. Winston. A science-fiction writer explores the future of space ships and interplanetary voyages. His predictions are based on scientific facts and theories.	6	3.95

Transportation

Big Wheels! Little Wheels! By Jene Barr. 32 pp. '55. Whitman. Simple sentences and many illustrations emphasize the importance of wheels in our daily lives.	1	1.25
Fast Trains! Busy Trains! By Jene Barr. 32 pp. '56. Whitman. A picture of life on a cross-country train trip. Also explains the different types of cars that make up the train and the duties of the people who work in the cars.	1	1.25
True Book of Transportation. By Elsa Posell. 46 pp. '57. Chil-		

	Grade	Price
dren's Press. . . . . Simple information about transportation from the day when man packed his belongings on his back and walked, to modern means. Large type and many illustrations.	2	$2.00
Military Vehicles. By C. B. Colby. 48 pp. '56. Coward-McCann Primarily a book of photographs with approximately one-third of each page devoted to text. Younger children will enjoy looking at the pictures of weapon carriers, L. C. Retrievers, ambulances, rocket launches and armed personnel carriers.	4	2.00
Railroads—Today and Yesterday. By Walter Buehr. 72 pp. '57. Putnam. . . . . A brief history of railroads and a description of the glamor trains and electronic automation of today. Illustrated with drawings by the author.	4	2.50
Trucks and Trucking. By Walter Buehr. 72 pp. '56. Putnam. . The story of trucking from earliest times through the modern age of our cargo-hauling trucks. Refrigerator trucks, oil trucks, livestock trucks, and many other types used in specialized industries are described and illustrated.	4	2.50
The First Book of Submarines. By J. B. Icenhower. 62 pp. '57. Watts. . . . . An officer of the U. S. Navy tells the story of submarine invention and operation and the use of submarines in warfare. Illustrations and text describe many types of submarines including the atomic powered *Nautilus.*	5	1.95
Helicopters Work Like This. By Basil Arkell and John W. Ransom. 62 pp. '57. Roy. . . . . Although this is a British publication, the information given on the history, operation, types, uses and future of helicopters is applicable to this country.	5	2.50
How Automobiles Are Made. By David C. Cooke. 64 pp. '57. Dodd. . . . . A concise account of the manufacture of automobiles and their importance to our life and economy. Authentic photographs illustrate each step.	5	1.95
Model Planes for Beginners. By H. H. Gilmore. 96 pp. '57. Harper. . . . . This revised edition gives detailed instructions for building a number of different models. It includes chapters on the history of flying, how a plane flies, identifying planes and the United States Air Force.	5	2.25
How Atomic Submarines Are Made. By David C. Cooke. 64 pp. '57. Dodd. . . . . The building of the *Nautilus,* the first atomic submarine, is described in detail and illustrated by photographs.	6	1.95
Miscellaneous		
Now This Now That—Playing with Points of View. By Howard Baer. 32 pp. '57. Holiday. . . . . A cartoon book intended to encourage a child to be both imaginative and observing. The text is in large type and ends by saying "Far and near, up and down, little and big, real and pretend—it's all in the way I look at it."	1	2.25
Magic House of Numbers. By Irving Adler. 128 pp. '57. Day. . An introduction to the basis of our number system with	6	2.95

	Grade	Price
considerable emphasis on puzzles, tricks, and games. Helpful for a teacher who needs ideas on how to make the study of arithmetic more interesting.		
Understanding Maps. By Beulah Tannenbaum and Myra Stillman. 141 pp. '57. Whittlesey. Includes map reading, construction and use, and simple experiments demonstrating navigational devices. Simple charts and diagrams are easily understood.	6	$2.75
How to Make a Miniature Zoo. By Vinson Brown. 212 pp. Revised Edition. '57. Little, Brown. Plans and procedures for establishing and maintaining a home or school zoo with size ranging from the simple cage, terrarium, or aquarium to the larger outside zoo. Identifies insects and their relatives, fish, amphibia, reptiles, birds and mammals that may be included in the zoo and describes critical stages of their natural history to assist the novice zookeeper.	6	2.75
Madame Curie. By Eileen Bigland. 191 pp. '57. Criterion Books. An extremely readable and authentic biography of the famous woman scientist. Her personal life is portrayed as well as her scientific achievements.	6	3.00

Publishers and Their Addresses

Capitol: Capitol Publishing Company, Inc., 737 Broadway, New York 3, New York.
Children's Press: Children's Press, Jackson Blvd. and Racine Avenue, Chicago 7, Illinois.
Coward-McCann: The John Day Company, 121 Sixth Avenue, New York 13, New York.
Criterion Books: Criterion Books, Inc., 100 Fifth Avenue, New York 11, New York.
Crowell: Thomas Y. Crowell Company, 432 Fourth Avenue, New York 16, New York.
Day: The John Day Company, 121 Sixth Avenue, New York 13, New York.
Dodd: Dodd, Mead and Company, Inc., 432 Fourth Avenue, New York 16, New York.
Doubleday: Doubleday and Company, Inc., 575 Madison Avenue, New York 22, New York.
Dutton: E. P. Dutton and Company, Inc., 300 Fourth Avenue, New York 10, New York.
Garden: Garden City Books, 575 Madison Avenue, New York 22, New York.
Grosset: Grosset and Dunlap, Inc., 1107 Broadway, New York 10, New York.
Harcourt: Harcourt, Brace and Company, Inc., 383 Madison Avenue, New York 17, New York.
Harper: Harper and Brothers, 49 East Thirty-third Street, New York 16, New York.
Holiday: Holiday House, 8 West Thirteenth, New York 11, New York.
Houghton: Houghton Mifflin Company, 2 Park Street, Boston 7, Massachusetts.
Knopf: Alfred A. Knopf, Inc., 501 Madison Avenue, New York 22, New York.
Little, Brown: Little, Brown and Company, 34 Beacon Street, Boston 6, Massachusetts.
Lippincott: J. B. Lippincott Company, 227–231 South Sixth Street, Philadelphia 5, Pennsylvania.
Lothrop: Lothrop, Lee and Shepard Company, Inc., 419 Fourth Avenue, New York 16, New York.

Macmillan: The Macmillan Company, 60 Fifth Avenue, New York 11, New York.
Morrow: William Morrow and Company, 425 Fourth Avenue, New York 16, New York.
Oxford: Oxford University Press, 114 Fifth Avenue, New York 11, New York.
Prentice-Hall: Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, New York.
Putnam: G. P. Putnam's Sons, 210 Madison Avenue, New York 16, New York.
Rand: Rand McNally and Company, 111 Eighth Avenue, New York 11, New York.
Random: Random House, Inc., 457 Madison Avenue, New York 22, New York.
Roy: Roy Publications, 25 West Forty-fifth Street, New York 19, New York.
Scribner: Charles Scribner's Sons, 597 Fifth Avenue, New York 17, New York.
Simon: Simon and Schuster, Inc., 630 Fifth Avenue, New York 20, New York.
Steck: Steck Company, Ninth and Lavaca Streets, Austin 1, Texas.
Sterling: Sterling Publishing Company, Inc., 121 East Twenty-fourth Street, New York 10, New York.
Watts: Franklin Watts, Inc., 699 Madison Avenue, New York 21, New York.
Whitman: Albert Whitman and Company, 560 West Lake Street, Chicago 6, Illinois.
Winston: John C. Winston Company, 1006–1020 Arch Street, Philadelphia 7, Pennsylvania.
Whittlesey: McGraw-Hill Company, 330 West Forty-second Street, New York 36, New York.
World: World Book Company, 313 Park Hill Avenue, Yonkers 5, New York.

HIGH SCHOOL CHEMISTRY TEST, TWO NEW TESTS, ARE FEATURED BY THE ACS EXAMINATIONS COMMITTEE

The examinations Committee of the Division of Chemical Education ACS has launched the 1958 Testing Program.

A new test has been prepared by the General Chemistry sub-committee under the chairmanship of Dr. Donald D. Wright of Brooklyn College. As an experiment the test has been released simultaneously in two forms, 1958 and 1958S. Both forms contain identical items, but in different order. This will help minimize copying, when used in the same examination room under crowded conditions, or in different sections during the day.

The Organic Chemistry sub-committee, under the chairmanship of Dr. Bernard A. Nelson of Wheaton College has prepared a new test, Organic Chemistry, Form 1958. The test is for a full year course, but a part may be given at the end of the first semester, or the entire test at the end of the year.

The High School Chemistry Test, Form N, has gone through a second printing. The test was prepared under the chairmanship of Mr. Elbert C. Weaver of Phillips (Andover) Academy and a sub-committee of 42 teachers appointed jointly by the Examinations Committee and the National Science Teachers Association.

The Spring 1958 program features tests in all fields of undergraduate chemistry: General Chemistry, Qualitative Analysis, Quantitative Analysis, Organic Chemistry, Physical Chemistry and Biochemistry. Several forms are available for each field, and national norms have been calculated in all but the new tests.

Further information and copies of all the tests may be obtained from Theodore A. Ashford, Committee Chairman, St. Louis University, St. Louis 4, Missouri. These tests are available to members of the faculty of higher educational institutions. Please use official stationery and use the official channels of the college when making inquiries. Limited copies of older examinations are available in addition to the tests featured in the testing program.

PROGRESS REPORT ON THE PROPOSED PROGRAM FOR THE 1958 CONVENTION

CLYDE T. MCCORMICK

Vice-President, CASMT
Illinois State Normal University,
Normal, Illinois

The planning for the 1958 annual convention of the Central Association of Science and Mathematics Teachers began at the meeting of the incoming section officers which was held on the last day of the 1957 convention. The first point considered was a general theme to be adopted for the 1958 convention. The best general theme suggested at that time seemed to be "The Challenge of Science and Mathematics in a Free World." We surely all agree that the *Challege* presents us with a deep and sobering concern for the future of civilization. The other point considered concerned the pattern for the convention. Even though the pattern followed in Chicago proved highly successful, those present felt that there might be a need for certain modifications in order to meet the situations and conditions in Indianapolis (1958). Several suggestions were given to throw light on this problem. The two problems considered by the Section Officers were presented to the Board of Directors for their consideration.

The general theme suggested by the section officers and also a number of basic questions regarding possible changes in the structure of the program were sent to the officers, directors, section chairman and selected leaders of the Association for their critical examination and suggestions. Several excellent suggestions were made and much sound advice was received. After a very careful study was made of these responses, an analysis and summary of a proposed program was sent to Mr. Louis Panush (the President), Mr. Ray Soliday (Treasurer—Business Manager), Mr. Edward Bos (President in 1957), and James Otto (The Local Coordinator). Then, through considerable correspondence with them, the final form of the program was evolved.

Below is a brief outline of the planned program for the 1958 convention built around the theme "The Challenge of Science and Mathematics in a Free World." More details will be given in subsequent issues.

On Thursday evening, November 27, there will be an Open Board Meeting on the theme "How is the CASMT to meet the Challenge?" on the different levels. A panel of three members representing elementary, junior high, and senior high will consider this problem.

On Friday morning, November 28, there will be a well-known mathematician who will address the Association on a topic in line with the general theme. Following this address a fine demonstration lecture will be given by a top scientist.

On Friday afternoon a great program is being planned. It will be divided into three parts. The Physical Science Study Committee, Cambridge, Massachusetts, will put on a 3½ hour program (plus 15 minute coffee break). The University of Illinois Committee on School Mathematics will also give a 3¼ hour program plus a 15 minute break. Tours to Pitman Moore, a biological company, and also to the Allison Division of General Motors at one of the Speedway plants, are being planned for the afternoon. No dinner is planned for Friday evening.

On Friday evening at 8:00 another Nobel Prize Winner, Dr. H. J. Muller, Indiana University, has already accepted the invitation to address the Association. Professor Muller will speak on "A Hundred Years without Darwinism are Enough."

On Saturday morning, 9:00–9:40, November 29, Professor A. J. Lohwater, Department of Mathematics, University of Michigan, will address the Association on "A Comparison of the Soviet and American Programs in Science and Mathematics Education." The rest of the morning will be given over to Section Meetings nearly half of which have already completed their program plans.

PROBLEM DEPARTMENT

CONDUCTED BY MARGARET F. WILLERDING
San Diego State College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution as *on the following pages.*

The editor of the Department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, San Diego State College, San Diego, Calif.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Solutions should be in typed form, double spaced.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

4. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

2546. *Howard D. Grossman, New York, N. Y.*

2592. *Myron E. White, Hoboken, N. J.*

2593. *Julian H. Braun, Chicago, Ill.*

2513. *Proposed by Joseph Kennedy, Madison, Wis.*

What groups are isomorphic to the Klein Four Group?

Solution by Calvin V. Holmes, San Diego, Calif.

The Klein Four Group K is the permutation group with elements

$$(1)(2)(3)(4),\quad (12)(34),\quad (13)(24),\quad (14)(23).$$

If e denotes the identity element of any isomorphic group G and a, b, c denote the distinct nonidentity elements of G, then the multiplication table for G is given by,

$$a^2=b^2=c^2=e \tag{1}$$

$$ab=ba=c,\ ac=ca=b,\ bc=cb=a \tag{2}$$

$$ex=xe=x,\ x \text{ any element of } F. \tag{3}$$

Each of the nonidentity elements of G have order two since the nonidentity elements of K have order two, hence equality (1). Consider the product ab,

$$ab=e \Longrightarrow b=a$$

$$ab=a \Longrightarrow b=e$$

$$ab=b \Longrightarrow a=e$$

but a, b, c are distinct nonidentity elements, hence $ab=c$.

The isomorphic image of an abelian group is abelian, hence G is abelian, and $ab=ba=c$. The remaining equalities of (2) follow in a like manner, and (3) is a result of the choice of e as the identity of G.

A solution was also offered by William E. Briggs, Boulder, Colo.

2605. *Proposed by C. W. Trigg, Los Angeles City College, Los Angeles, Calif.*

Show that the area of an acute triangle is equal to $\frac{1}{2}RP$ where R is the radius of the circumcircle of the triangle and P is the perimeter of pedal triangle of the orthocenter.

Method I.—Solution by C. N. Mills, Sioux Falls College, Sioux Falls, S. D.

Analytic solution. Let the triangle be represented by the points $A(-2a,0)$, $B(2b,0)$, and $C(0,2c)$. The circumradius (R) of the triangle ABC is

$$\frac{4c^2(a+b)}{\sqrt{(a^2+c^2)(b^2+c^2)}}.$$

The perimeter (P) of the pedal triangle LMN is

$$\frac{\sqrt{(a^2+c^2)(b^2+c^2)}}{c}.$$

$\frac{1}{2}RP=2c(a+b)$, which is the expression for the area of the triangle ABC.

Method II.—Solution by the proposer

Let the feet of the attitudes from A, B, C be A', B', C', respectively. Then $AB'=c\cos A$ and $AC'=b\cos A$. By the law of cosines,

$$\begin{aligned}(B'C')^2&=(c\cos A)^2+(b\cos A)^2-2bc\cos^2 A\cos A\\&=\cos^2 A(c^2+b^2-2bc\cos A)=a^2\cos^2 A.\end{aligned}$$

Hence $B'C'=a\cos A$, and in like manner, $C'A'=b\cos B$ and $A'B'=c\cos C$. We now have

$$\begin{aligned}P&=a\cos A+b\cos B+c\cos C\\&=a(b^2+c^2-a^2)/2bc+b(a^2+c^2-b^2)/2ac+c(a^2+b^2-c^2)/2ab\\&=(2a^2b^2+2b^2c^2+2c^2a^2-a^4-b^4-c^4)/2abc\\&=16s(s-a)(s-b)(s-c)/2abc=8\Delta^2/4\Delta R=2\Delta/R,\end{aligned}$$

where S is the semi-perimeter and Δ is the area of triangle ABC. Therefore, $\Delta=\frac{1}{2}RP$.

2606. *No solution has been offered.*

2607. *Proposed by Brother Felix John, Philadelphia, Pa.*

Find general formulas to express two positive integers which are such that the result obtained by adding their product to the sum of their squares is a perfect square.

Solution by C. W. Trigg, Los Angeles City College

A two-parameter solution of $x^2+xy+y^2=z^2$ is

$$\begin{aligned}x&=m^2-n^2\\y&=2mn+n^2\\z&=m^2+mn+n^2\end{aligned}$$

where $m>n$.

A solution was also offered by Dennis Bradley, San Diego Calif.; and the proposer.

2608. *No solution has been offered.*

2609. *Proposed by Cecil B. Read, Wichita, Kan.*

A man cashes a check at the bank. By mistake the teller pays him the number of cents as dollars and the number of dollars as cents. The man spends \$3.50 before he notices the mistake, then when he counts his money he finds he has left exactly double the amount of the check. For what amount was the check drawn?

Solution by H. R. Leifer, Verona, Pa.

Let

$$1000a+100b+10c+d$$

be the amount for which the check is drawn, then

$$2(1000a+100b+10c+d)=1000c+100d+10a+b-350$$

$$7(10c+d)-25=\frac{199(10a+b)}{2\cdot 7}.$$

Let

$$(10a+b)=14n,$$

then

$$7(10c+d)-25=199n.$$

Since

$$(10c+d)\leq 99,\ 199n\leq 668$$

$$0<n\leq 3.$$

But

$$199n+25\equiv 0 \pmod 7$$

$$\therefore\ n=1.$$

From

$$(10a+b)=14n,\ a=1,\ b=4.$$

From

$$7(10c+d)-25=199n,\ c=3,\ d=2.$$

Thus the check was drawn in the amount \$14.32.

Solutions were also offered by Gerald E. Doeden, Muncie, Ind.; B. Greenberg, Fort Hamilton High School; Margaret Joseph, Milwaukee, Wis.; F. A. Lee, Jr., Marion, Ala.; Thomas MacDowell, San Diego, Calif.; J. H. Means, Huston-Tillotson College; Estel Miller, Galena, Ohio; C. N. Mills, Sioux Falls, S. D.; Bernard T. Pleimann, Gardena, Calif.; Oliver Shannon, Pine Bluff, Ark.; C. W. Trigg, Los Angeles, Calif.; Herb Wills, Elmhurst, Ill.; Dale Woods, Pocatello, Idaho; and the proposer.

2610. *Proposed by A. Elliott, San Diego, Calif.*

Given 12 balls, 11 of which are identical and one of which is either lighter or heavier than the others. Find the odd ball and determine whether it is light or heavy using only 3 weighings on a simple balance.

Solution by Hermann Boeckmann, Bloomington, Ill.

Divide the 12 balls into 4 groups of 3 balls each.

A *B* *C* *D*

Weighing #1

Weigh groups *A* and *B*. If *A* and *B* does not balance, we should note which group is the heaviest. (See situation *A*) If *A* and *B* balanced, the odd ball must either be in group *C* or *D*. (See situation *B*)

Situation A:

Choose the heavier group of groups *A* and *B*.

Weighing #2

Weigh group C (which contain balls of the same weight) and the heavier group of A and B. If it balances, we know that the odd ball is one of the balls of the lighter group of the first weighing. Also we know the odd ball is light.

If it does not balance, we know the odd ball is in the heavier group of the first weighing. Also we know that the odd ball is heavy.

Weighing #3

Since we know in the last weighing whether the odd ball is light or heavy, divide the group which contains the odd ball in 3 groups of 1 ball each.

Weigh 2 of the balls. If it balances we know the remaining ball is the one we want. If it does not balance, we can tell which ball it is by the result we obtained from the first weighing.

Situation B:

In this case, the odd ball is either in group C or D.

Weighing #2

Weigh group B (which in this case has 3 balls of the same weight) and group C. If it does not balance, we can tell that group C is heavier or lighter by comparing it with group B. From this we can tell whether the odd ball is heavy or light. Then use the same procedure in the third weighing as in situation A.

If group B and C balanced, then the odd ball is in group D. If the odd ball is in group D, then we can use the same procedure of dividing the group into 3 groups of 1 ball each. Then use the procedure as we used in situation A for the third weighing. This will determine what ball is the odd ball. However, this will not determine whether it is heavy or light as compared to the other balls.

If the ball is in group D, one must use four weighings. The probability of the ball being in the first three groups is 75% or 25% in the last group.

Thus the above procedure will work in 100% of the cases in locating the ball, but it will work only 75% of the cases in determining whether this odd ball is heavy or light using only 3 weighings.

Solutions were also offered by Sr. Mary Constance, Fond du Lac, Wis.; Gerald E. Doeden, Muncie, Ind.; Benjamin Greenberg, Fort Hamilton High School; H. R. Leifer, Verona, Pa.; Thomas MacDowell, San Diego, Calif.; Estel Miller, Galena, Ohio; Julius Sumner Miller, El Camino, Calif.; Murray Pollitt, Toronto, Canada; Sister Rita, Washington, D. C.; M. C. Rowan, Jr., Washington, D. C.; and Dale Woods, Pocatello, Idaho.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

The Student Honor Roll for this issue appears below.

2609. *Leonard Myers, Bloomington High School, Bloomington, Ill.*

EDITOR'S NOTE: THERE IS A NEED BY THE EDITOR FOR SOME GOOD PROBLEMS. WHY NOT SPEND PART OF THE SUMMER VACATION THINKING UP SOME INTERESTING PROBLEMS TO SEND TO THE EDITOR OF THE PROBLEM DEPARTMENT?

PROBLEMS FOR SOLUTION

2629. *Proposed by C. N. Mills, Sioux Falls College, S. D.*

Given $f(x)=ax^2+bx+c$ and $g(x)=cx^2+bx+a$. Show that $f(x)$ and $g(x)$ have a common linear factor when $(a+c)=\pm b$.

2630. *Proposed by James H. Means, Austin, Texas*

If m and n are positive integers, show that

$$mn(m^2-n^2)$$

has 0, 4, or 6 as its units digit.

2631. *Proposed by C. W. Trigg, Los Angeles City College.*

The lengths in inches of the edges of three cubes are consecutive odd integers. When piled on a floor, one on top of the other, with edges parallel, the area of the exposed surface is 1229 sq. in. Find the edges and the order of piling.

2632. *Proposed by A. R. Haynes, Tacoma, Wash.*

The normals at three points P, Q, R of a parabola meet in the point O. Prove that

$$SP+SQ+SR+SA=2[OM]$$

where S is the focus and OM the perpendicular from O on the tangent at the vertex.

2633. *Proposed by A. L. Elliott, San Diego, Calif.*

What are the rational solutions of $x^y=y^x$ with $y>x>0$?

2634. *Proposed by E. M. Edwards, San Diego, Calif.*

A Census Taker recently made some interesting observations: The population of East Jalopy at one time was a perfect square. Later when the population had increased by 100, it was one more than a perfect square. But now, since the population has increased by another 100, it is again a perfect square. What is the present population of East Jalopy?

CHEMICAL EXPERIMENTS PRODUCE POWER DIRECTLY FROM ENERGY

Converting energy directly into electricity is now the subject of experiments using fuel cells and thermoelectric generators as possible future sources of power.

These experiments, now only in early laboratory stages, were described and demonstrated by the manager of the technology department of the Westinghouse Research Laboratories.

Discussing these efforts to by-pass the usual fire-steam-electricity cycle, scientists said that further advances in direct power conversion greatly depend on the work of research chemists. They cited the chemical preparation of suitable materials, analysis of their composition and study of their behavior under high temperatures as typical problems to be solved by modern chemistry.

NEW BACTERICIDAL GAS MAY AID STERILIZATION

A new bactericidal gas which promises to be highly useful as a sterilizer in operating rooms, hospitals and nurseries has been described.

The gas is known as beta-propiolactone. Developed by the U.S. Army Chemical Corps scientists, it was formerly used only in aqueous solutions.

The gas acts as effectively as formaldehyde vapor but works more rapidly and with fewer adverse side effects.

BOOKS AND TEACHING AIDS RECEIVED

BASIC TELEVISION, by A. Schure. Paper, 5 volumes. Pages: 1–112; 2–145; 3–137; 4–122; 5–135. 15×23 cm. 1958. John F. Rider Publishing Co., Inc., 116 W. 14th St., New York 11, N. Y. Price $2.25 for each volume.

SCIENCE FOR ALL, An Annotated Reading List, Prepared in consultation with The British Association for the Advancement of Science. Cloth. Pages viii+177. 12×18.5 cm. 1958. Cambridge University Press, 32 E. 57th S., New York 22, N. Y. Price $2.00.

FILMSTRIPS—CAREERS IN SCIENCE, Grades 7–9. Four filmstrips: "Looking Ahead to Chemistry," Looking Ahead to Biology," "Looking Ahead to Physics," and "Looking Ahead to Mathematics." Charles Scribner's Sons, 597 5th Ave., New York 17, N. Y. Price, $4.00 each, or $14.00 for set of four.

NUMBERS WE NEED, Primer by William A. Brownell and J. Fred Weaver. Paper. 80 pages. 21×27.5 cm. 1958. Ginn and Co., Statler Building, Boston 17, Mass. Price. $.76.

NUMBERS WE NEED, Book One, by William A. Brownell and Fred Weaver. Paper. 96 pages. 21×27.5 cm. 1958. Ginn and Co., Statler Building, Boston 17, Mass. Price $.84.

BIOLOGY SERVING YOU, by Charles Gramet and James Mandel. Cloth. Pages v+616. 17.5×23 cm. 1958. Prentice-Hall, Inc., Englewood Cliffs, N. J. Price $4.96.

TEACHERS OF CHILDREN WHO ARE SOCIALLY AD EMOTIONALLY MALADJUSTED, by Romaine P. Mackie, William C. Kvaraceus, and Harold M. Williams. Paper. Pages xi+92. 15×23 cm. 1957. Bulletin 1957, No. 11. Office of Education, U. S. Department of Health, Education, and Welfare. Price $.45.

BIOLOGY—THE LIVINGWORLD, by Francis D. Curtis, *University of Michigan* and John Urban, *State University Teachers College, Buffalo.* Cloth. Pages xiii +705. 17.5×23 cm. 1958. Ginn and Co., Statler Building, Boston 17, Mass. Price $4.96.

SCIENCE IN DAILY LIFE, NEW EDITION, by Francis D. Curtis, *University of Michigan* and George G. Mallinson, *Western Michigan University, Kalamazoo.* Cloth. Pages xi+580. 17.5×23 cm. 1958. Ginn and Co., Statler Building, Boston 17, Mass. Price $4.48.

THE PHILOSOPHY OF HUMANISM, by Corliss Lamont Cloth. Pages xi+243. 11×18.5 cm. 1957. Philosophical Library, Inc., 15 E. 40th St., New York 16, N. Y. Price $2.75.

PRINCIPLES OF BIOLOGY, 2nd Ed., by W. Gordon Whaley, Osmond P. Breland, Charles Heimsch, Austin Phelps, and A. R. Schrank. Cloth. Pages x+877. 16.5 ×23.5 cm. 1958. Harper and Bros., 49 E. 33rd St., New York 16, N. Y. Price $6.75.

HANDBOOK OF CALCULUS, DIFFERENCE, AND DIFFERENTIAL EQUATIONS, by Edward J. Cogan, *Sarah Lawrence College*, and Robert Z. Norman, *Dartmouth College.* Cloth. Pages xii+263. 14.5×23 cm. 1958. Prentice-Hall, Inc., Englewood Cliffs, N. J. Price $4.50.

COMMUNICATION, ORGANIZATION, AND SCIENCE, by Jerome Rothstein. Cloth. Pages xcvi+110. 13×20.5 cm. 1958. The Falcon's Wing Press, Indian Hills, Colorado. Price $3.50.

ME AND FRUMPET, by Evans G. Valens. Cloth. 127 pages. 17.5×23 cm. 1958. E. P. Dutton and Co., Inc., 300 4th Ave., New York 10, N. Y. Price $2.75.

COUNTDOWN FOR TOMORROW, by Martin Caidin. Cloth. 288 pages. 14×20 cm. 1958. E. P. Dutton add Co., Inc., 300 4th Ave., New York 10, N. Y. Price $4.95.

GASEOUS CONDUCTORS, by James Dillon Cobine, *Physicist, General Electric Research Laboratory.* Paper. Pages xv+606. 13.5×20.5 cm. 1958. Dover Publications, 33 E. 19th St., New York 10, N. Y. Price $2.75.

WATER TREATMENT PLANT KIT, for upper elementary and junior high school science. Model, duplicating all the steps of a community water treatment plant. Kit includes: Illustrated teacher's manual; Reservoir Tray, 20.5×28″; Water Treatment Tray, 20.5×28″; Motor-driven Centrifugal Pump; Chemical kit; pH paper; filter paper; zeolite; fine sand; course sand; gravel; rubber tubing; dry algae; soap powder; alum feeder; aerating fountain; baffle; measuring cup, spoons; worksheets for students. Product Design Co., 2796 Middlefield Rd., Redwood City, California. Price of Kit: $79.95; Heavy Duty Battery, $2.45; Carrying Case, $14.95.

BUSY WATER, by Iram Simonton Black. Cloth. Unpaged. 18×23 cm. 1958. Holiday House, 8 W. 13th Street, New York 11, N. Y. Price $2.50.

I LIKE CATERPILLARS, by Gladys Conklin. Cloth. Unpaged. 18×23 cm. 1958. Holiday House, 8 W. 13th Street, New York 11, N. Y. Price $2.75.

FIGURETS, More Fun With Figures, by J. A. H. Hunter. Cloth. 116 pages. 12.5×19 cm. 1958. Oxford University Press, 114 5th Ave., New York 11, N. Y. Price $3.50.

PLANE GEOMETRY FOR COLLEGES, by L. J. Adams, *Santa Monica City College.* Cloth. Pages v+214. 14×21 cm. 1958. Henry Holt and Co., 383 Madison Avenue, New York 17, N. Y. Price $3.50.

AIR, WINDS, AND WEATHER, by J. Myron Atkin and R. Will Burnett, *University of Illinois.* Paper. Pages vi+ 58.05×23 cm. 1958. Rinehart and Co., Inc., 23 Madison Ave., New York 16, N. Y. Price $1.00.

THE RADIO AMATEUR'S HANDBOOK, by The Headquarters Staff of the American Radio Relay League. Paper. 111 pages. 16.5×24 cm. 1958. American Radio Relay League, West Hartford 7, Conn. Price $3.50.

MATHEMATICAL FOUNDATIONS OF INFORMATION THEORY, by A. I. Khinchin. Paper. 120 pages. 1958. Dover Publications, Inc., 920 Broadway, New York 10, N. Y. Price $1.35.

A BIBLIOGRAPHY OF REFERENCE BOOKS FOR ELEMENTARY SCIENCE, by George G. Mallinson and Jacqueline V. Buck. Paper. Pages iv+35. 21.5×28 cm. 1958. National Science Teachers Association, 1201 16th St., N. W., Washington, D. C. Price $.50.

MATHEMATICS IN BUSINESS, by Lloyd L. Lowenstein, *Arizona State College, Tempe* Cloth. Pages xv+364. 15×23 cm. 1958. John Wiley and Sons, Inc., 440 4th Ave., New York 16, N. Y. Price $4.95.

ANALYTIC GEOMETRY, by Edwin J. Purcell, *University of Arizona.* Cloth. Pages x+289. 15×23.5 cm. 1958. Appleton-Century-Crofts, Inc., 35 W. 32nd St., New York 1, N. Y. Price $4.50.

ARITHMETIC FOR COLLEGES Rev. Ed., by Harold D. Larsen, *Albion College.* Cloth. Pages xiii+286. 13.5×20 cm. 1958. The Macmillan Co., 60 5th Ave., New York 11, N. Y. Price $5.50.

THE RISE AND FALL OF YE DISTRICT SCHOOL IN PLYMOUTH PLANTATION (1800–1900), by William Gould Vinal, "Cap'n Bill," Ph.D. *Emeritus Professor of Nature Education, University of Massachusetts at Amherst.* Cloth. Pages 144. 21×28 cm. 1958. A Vinehall Publication, Norwell, Mass.

BOOK REVIEWS

LEARNING TO USE ARITHMETIC SERIES, by F. Lynwood Wren, J. Wayne Wrightstone, Joseph H. Randall, Agnes G. Gunderson, Joseph J. Urbancek, and George E. Hollister. D. C. Heath and Company, Boston, Massachusetts, 1958.

This series of elementary arithmetic textbooks represents a new entry into a field in which there is already much excellent material available. It is therefore doubly important that new material be of an oustanding nature if it is to be considered at all by potential users. In the opinion of the reviewer this new series by D. C. Heath and Company qualifies in most respects for worthy consideration by arithmetic textbook users. It is complete with textbooks and teachers' manuals for grades 1 to 6 as well as workbook supplements for grades 3 through 6. Beginners and first and second grade books are of the usual expendable paper cover variety and books 3 through 6 have white cloth covers. It is understood that the series continues through grades 7 and 8 but these books were not available to the reviewer.

The authors indicate in the preface to the teachers' editions that it is their belief that arithmetic content such as number concepts and their applications through the fundamental processes must be presented as a "full circle—not once but again and again in ever-widening circles." In the opinion of the reviewer this objective of "ever-widening" the scope of the arithmetic as presented to the student at successive grade levels has been adequately accomplished in the series.

It is particularly desirable that materials be carefully chosen at each new grade level to challenge the student in terms of the added maturity which he possesses and to obtain a more complete understanding of the processes of arithmetic which he will be expected to apply to everyday lifes ituations.

A rather important part of these books then would be those portions devoted to building a better understanding of the fundamental processes in terms of meanings; and how an understanding of these meanings can be applied to determine problem solution. Typical of how the series attacks this problem is an exercise on page 75 of Book Four, in which the student has to decide whether to *add* or *multiply*. The decision in each problem is to be made in terms of the similarities and differences between the two related processes. Thus, a fine distinction between the application of the two processes is developed.

Other catchy, self-descriptive titles which recur throughout the series are:

Practice to Remember
Finding What You Need to Study Again
"Make Up" Problems
Estimating Answers
What Have You Learned About ————
Problems with Two (or more) Steps, Shapes, and Sizes
Problems on Many Topics Just for Fun
Problems Without Numbers

The usual material for each grade is presented in a manner which is meaningful and which should do much to build the adequate understandings and skills required at each grade level. No attempt has been made to over-simplify the arithmetic which must be required in each grade if the student is to mature properly his number sense. Each textbook ends with a final test over the year's work which might also be used by the student for self-evaluation as well.

Another excellent example of how the meaning of the processes is emphasized may be found in the further development of the division concepts in the sixth grade book. Division is characterized as *Finding the Number* or *Finding the Size*. These "Measurement" and "Partition" concepts are summarized as:

Two Reasons for Dividing

"One reason for dividing is to find the number of small groups, all the same size, that are contained in a larger group.

"Another reason for dividing is to find how many there are in each small group when you make a number of equal small groups from a larger group."

The manuals are unique in that they are of the loose-leaf variety in which the teacher's helps are in the first part of the binder, followed by a complete, full-sized student's edition on the pages of which the answers to the problems have been superimposed in blue. The manuals may thus be rearranged to place teacher-helps next to student pages, or possibly by chapters, or in any other way to suit the teacher. The result is a rather large bulky volume for the teacher to handle but one which will lie flat on her desk and stay open at the desired pages and materials. Some tendency for sheets to tear out will undoubtedly be noted also.

Materials within the manuals are called Guides to the use of each student page. These "guides" provide for each lesson in the Beginners Book and Books One and Two a statement of the purpose of each lesson, a review of the needed background understandings; a procedure for using the book; and finally some related activities. The manuals for grades 3 to 6 include also suggestions for using the materials and means of evaluation.

The series in general is very colorful and attractive although the reviewer felt that additional color might have been used in certain portions of the second grade book. The paper used is excellent from the standpoint of durability and lack of glare. The white covers (washable) would seem to be a questionable choice of color. Vocabulary is well chosen for each grade level and while an adequate mathematical vocabulary is being developed, words not commonly used, such as minuend and multiplicand are "reserved" for the teacher's manuals.

Other unique features of the series include the colored squares and circles (cut-outs) included in Books One and Two for the students to use as counters in establishing the meanings of addition, subtraction, and simple multiplication concepts, as well as for making semi-concrete visualizations of many of the problems. Number lines are used also in Books Three and Four to help visualize the multiplication and division facts. Fraction concepts are clearly illustrated by colorful diagrams. Many problems in division are completely worked out to illustrate the methods which may be used to estimate quotient figures.

The conclusion of the reviewer is that this new series is worthy of consideration along with the best of the well-established series which are currently finding favor among school administrators, teachers and ultimately with the students for whom the textbooks were intended.

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PRINCIPLES IN BIOLOGY, Second Edition, by W. Gordon Whaley, *Professor of Botany, University of Texas;* Osmond P. Breland, *Professor of Zoology, University of Texas;* Charles Heimsch, *Professor of Botany, University of Texas;* A. R. Schrank, *Associate Professor of Zoology, University of Texas;* and Austin Phelps, *Associate Professor of Zoology, University of Texas.* Cloth. Pages x +877. 16×23.5 cm. 1958. Harper and Brothers, 49 East 33rd Street, New York 16, New York. Price $6.75.

The well-qualified University of Texas group can well be proud of their fine effort. This book can as readily be employed in a foundation course for the biology major as in a survey course for the general education student. Even secondary schools may find the text useful in advanced biology courses.

Biological principles are set forth clearly and pertinent discussion is neither too brief nor two detailed. Illustrations are well chosen and in most instances serve a useful purpose. The large type makes the book most readable and the very bold type employed to subdivide chapters contributes greatly to orderliness and enables the reader to follow even the difficult details of photosynthesis and respiration.

"Review questions" at the end of each chapter are missing, and biological terms, when introduced, are neither in bold type nor italics. This will be disappointing to many persons who have found such features helpful. Suggested readings at the end of each chapter are scholarly and well chosen.

Subject matter is well covered with major emphasis on function and development. The authors have divided the material into fifty-one chapters. Perhaps this division is too extensive, but excellent organization permits but few criticisms in this regard. The final chapter, Biology's Contribution to Man, adds little to the book, and the authors possibly could have included the material covered in the chapter entitled Health and Disease in the unit: Structure and Function in Higher Organisms. Many biology instructors teach function, malfunction and structure at the same time in a general course.

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ALGEBRA, BOOK ONE, Revised Edition, by A. M. Welchons, W. R. Krickenberger, and Helen R. Pearson, *The Arsenal Technical High School, Indianapolis, Indiana*. Cloth, Pages x+582. 15×23 cm. 1956. Ginn and Co., Statler Building, Boston, Mass. Price $3.28.

ALGEBRA, BOOK TWO, Revised Edition, by A. M. Welchons, W. R. Krickenberger, and Helen R. Pearson, *The Arsenal Technical High School, Indianapolis, Indiana*. Cloth. Pages x+582. 15×23 cm. 1957. Ginn and Company, Statler Building, Boston 17, Mass. Price $3.68.

Both Book I and II are revisions of the Welchons and Krickenberger books. Changes have been made in the sequence of topics and development of subject matter.

The authors aimed to meet the requirements of some modern courses of study and examining bodies, but obviously did not attempt to include the topics of sets, inequalities and other ideas of modern mathematics in Book I, as suggested recently by the College Entrance Examination Board Commission on Mathematics.

Book II however, includes such topics as the Binary System, p. 320, Statistics and Curve fitting, pp. 466–491, An Introduction to the Calculus, p. 494 ff., Inequalities, p. 556 and Mathematical Induction, p. 548.

One of the outstanding features of both books is the inclusion of many illustrated articles which point out the need in various professions and occupations for men and women trained in mathematics. Good examples in Book I are found on p. 58 "Mathematics used in Physics"; p. 126—"Do you wish to become an Architect?"; p. 156—"Women Engineers"; p. 182—"Radar"; p. 210—"Mathematics in Jet Engine Propulsion"; p. 298—"Rocket Power."

In Book II, p. 158—"Atomic Energy"; p. 244—"Space Travel"; p. 282—"Computing Machines"; p. 436—"Mathematics needed in Medicine and Medical Research."

Also especially good are the Visual Aids. There is much use of color for emphasis, many photographs and clever diagrams. Good examples in Book I are found on p. 199—"The principle of the lever"; p. 371—"You cannot do this!"; p. 375—"I forgot to invert."

In order to take care of individual differences among students, three levels of work are offered. The "A" topics are for everybody. The "B" topics are for the more ambitious and the "C" work is for the exceptional student. However, the first "C" work offered is found on p. 106, which seems rather late. In Book II the gifted student waits for page 121.

Some excellent "Rules of the Road" are presented on pp. 26–27 in Book I. For example: Danger: When you postpone your homework until "after awhile"; when you do not get help on the things you do not understand.

Teachers will like the reviews and tests provided at the end of each chapter. In fact, both books include both chapter and cumulative reviews, chapter check lists and chapter and cumulative tests. A separate book of tests is also available. Also included is a chapter "mathematical vocabulary" with the number of the page given where the term was first used or defined. The definitions are more carefully written than in many other texts. For example: "A *fractional equation* is one in which some function of the unknown appears in the denominator." (p. 113, Book II.)

One of the most difficult topics in the beginning course is that of Solution of Verbal problems involving, motion, mixture, work etc. The authors do an excellent job in showing the necessary steps on p. 250 of Book I; the chart method or "rectangular notation" for rate-time-distance problems is well done. But why not also illustrate how these charts would appear in "work" and "mixture" problems? The greatest help any teacher can give a student on verbal problem solutions, is to show the "chart method" of presenting the notation and given facts.

Probably some of the most careful and most complete work done by Welchons, Krickenberger and Pearson is evidenced by Chapters 4 and 5, Book II—they didn't miss a thing. Look at p. 101 ff. where "Fractions and Fractional Equations" are introduced. The purpose, the Fundamental Principle, the Law of Signs, what happens when an odd number of factors is changed, the two different meanings of cancellation marks, the many exercises providing for adequate drill, all these represent the "voice of experience."

As to the other side, there are no severe weaknesses in these books, except those they have in common with most Second Course texts, namely a lack of adequate Motivation for such topics as "theory of equations," (which is not even mentioned as such), "mathematical induction" and "inequalities." Wouldn't it provide additional motivation if some practical problems taken from Solid Geometry, Physics or Astronomy were included in the topic of Higher Degree Equations, p. 522, Book II?

The paper is excellent, the cover attractive, the size of print very adequate. Teachers who do not insist on the topics of sets and other "modern" topics will vote for these books.

A. S. RICHERT
East High School
Wichita, Kansas

TEACHING OF SCIENCE IN THE SECONDARY SCHOOL, by R. Will Burnett, *Professor of Science Education, University of Illinois.* Cloth. Pages xii+371. 17.5×25.5 cm. 1957. Rinehart and Co., Inc., 232 Madison Avenue, New York 16, New York. Price $5.25.

It sounds trite to say, "this book should be read by every science teacher, science educator, and prospective science teacher in the country." But, such a saying expresses the reviewer's opinion of this book. This book is not only a methods book, but one the experienced teacher should have on his desk to examine and ponder on its contents. The book is divided into five parts. "Part I presents the basic problems that must be faced and solved by the teacher if science teaching is to be made effective." Part II is devoted to an analysis of the critical problems of science teaching presented in Part I. Part III is devoted to methods for the improvement of classroom practice. Part IV consists of complete descriptions of how teachers taught different units in a core class, biology class, and programs for meeting the needs of talented students. Part V discusses the present status and predicted future of science teaching as a profession. To give the reader some idea of the scope of the book, the following is a partial list of the chapter headings. 1. Critical Problems of Modern Science Teaching. 3. The Historical Basis of Conventional Practices. 5. The Psychological Basis of Modern Science Teaching. 6. Newer Patterns of Course Offerings. 10. Diagnosis and Evaluation. 15. Science Teaching as a Profession.

The essential points of many research studies in science education are mentioned and an integral part of the different chapters. The bibliography is very complete and forms the basis of Parts I–IV.

As a science teacher, you may not agree with all the content, but the problems and possible solutions are defined and presented in a very clear manner.

E. WAYNE GROSS
University School
Bloomington, Indiana

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The Illinois Council of Teachers of Mathematics is pleased to announce the program for its tenth annual conference. The theme, "Mathematics in a Space-Minded Era," is a timely one and, fortunately, it was possible to secure speakers who are playing prominent roles in the changes taking place. All people interested in the teaching of mathematics are invited to attend. This includes the teachers of arithmetic.

Date: Saturday, October 4, 1958

Time: 8:30 A.M. to 3 P.M.

Place: Karl D. Waldo Junior High School, Aurora, Illinois

Theme: "Mathematics in a Space-Minded Era"

Principal Speakers:

Elementary Section:
"Recent Curriculum Trends"
Dr. Charlotte Junge
Wayne State University
Detroit, Michigan

Junior High School Section:
"The Junior High School and the New Mathematics"
Dr. John Mayor
Junior High School Project
University of Maryland

Secondary and College Section:
"Commission on Mathematics; Its Work and Recommendations"
Dr. Albert E. Meder, Jr.
Executive Director
Commission on Mathematics

General Session:
"The Modernizing of the Mathematics Curriculum"
Dr. W. W. Sawyer
Department of Mathematics
University of Illinois

Discussion Groups:

There will be nine discussion groups in the morning.

For further information contact:

Mrs. Donna Holroyd, President
Illinois Council of Teachers of Mathematics
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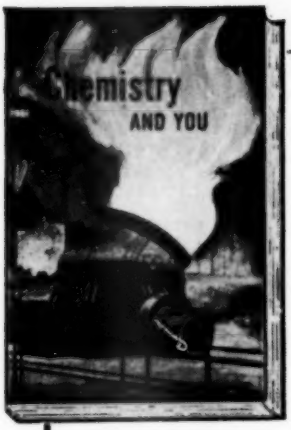

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